

OSCER State of the Center

Henry Neeman, Director

**OU Supercomputing Center for Education & Research
A Division of OU Information Technology**

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Wednesday September 30 2020
University of Oklahoma



Use Our Ugly Symposium Website!

Our ugly Symposium website

<http://symposium2020.oscer.ou.edu/>

has a complete agenda and speaker information.

It's so ugly that it's optimized for phones and tablets.

We encourage you to use it!



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THE UNIVERSITY OF OKLAHOMA

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Preregistration Profile 2020

- **Organizations**: 740 preregistered (or speaking) from 48 US states and 4 US territories (missing only AK, WY), plus 14 other countries on every continent except Antarctica
 - **Academic**: preregistered 229 institutions
 - Includes 79 academic institutions in 25 of 28 EPSCoR jurisdictions
 - **Industry**: preregistered 43 private companies
 - **Government**: preregistered 22 agencies (federal, state, non-US)
 - **Non-governmental/not-for-profit**: preregistered 16 organizations
- **Demographics**: 737 preregistered (and/or speaking)
 - 15% OU, 85% non-OU (or unknown)
 - 31% Oklahoma, 69% non-Oklahoma (or unknown)
 - 50% from EPSCoR states, 50% non-EPSCoR (or unknown)
 - 83% academic, 17% non-academic (or unknown)



Attendee Profile 2002-2019

- Over 4000 attendees at the previous 18 Symposia
 - 69 in 2002, 175-350 per year thereafter, typically 275 \pm 25
- Organizations: 362 2002-2019
 - **Academic**: from 127 institutions in 28 US states & territories plus 3 other countries
 - 66 institutions in 12 EPSCoR jurisdictions
 - 35 institutions in Oklahoma
 - PhD-granting, masters-granting, bachelors-granting, community colleges, career techs, high school
 - Historically Black University, Tribal College, 3 Native American Serving Non-tribal Institutions
 - public, private, for-profit
 - **Industry**: from 178 firms
 - **Government**: from 36 agencies (federal, state, municipal, foreign)
 - **Non-governmental/not-for-profit**: from 21 organizations



Symposium 2004-19 Sponsors: Thank You!

- Sponsors: 98 commercial, 7 non-commercial

Thank you all! Without you, past Symposia couldn't happen.

Of our 98 commercial sponsors, half have repeated (and/or were acquired by or merged with other sponsors).



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Thanks!

- OU IT
 - OU CIO David Horton
 - OSCER Operations Team: Dave Akin, Patrick Calhoun, Kali McLennan, Jason Speckman
 - OSCER Research Computing Facilitators: Jim Ferguson, Horst Severini
 - Jeremy Hessman, OU IT, for Zoom license help
 - All of the OU IT folks who helped put this together
- OneOklahoma Cyberinfrastructure Initiative (OneOCII)
 - Pratul Agarwal, OSU
 - Stephen Wheat, ORU



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Thanks: Plenary Speakers

- Amy Friedlander, National Science Foundation
- Susan Gregurick, National Institutes of Health
- Tom Lange, Technology Optimization & Management LLC
- John Shalf, Lawrence Berkeley National Laboratory
- Dan Stanzione, Texas Advanced Computing Center, University of Texas at Austin



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Thanks: Panel

- Moderator: James Deaton, Great Plains Network
- Pratul Agarwal, Oklahoma State U
- Brian Burkhart, OneNet
- Jeremy Evert, Southwestern Oklahoma State U
- Jim Ferguson, OU
- Karl Frinkle, Southeastern Oklahoma State U
- Peter Hawrylak, U Tulsa
- Evan Lemley, U Central Oklahoma
- Stephen Wheat, Oral Roberts U



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Thanks!

To all of you for participating, and to those many of you who've shown us so much loyalty over the past 18 years.



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Outline

- OU
 - Resources
 - Upcoming Resources
 - Accomplishments
- OCII/OneOCII



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Resources



Dell Intel Haswell HPC Cluster

Peak speed: 537 TFLOPs* (base), 730 TFLOPs (max turbo)

*TFLOPs: trillion calculations per second

705 compute nodes

1408 CPU chips: Intel Xeon

“Haswell,” “Broadwell,”
“Skylake,” “Cascade Lake,” “Rome,”
“Knights Landing,” “Sandy Bridge”

16,608 CPU cores

45 TB RAM

500+ TB global public disk

3 PB global condominium disk

Mellanox FDR10 Infiniband

(3:1 oversubscribed, 13.33 Gbps,
~1 microsec latency)

Dell N-series Gigabit/10G Ethernet

CentOS 7.8

52% of the nodes are “condominium”
(owned by individual research teams).



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Photo: Jawanza Bassue



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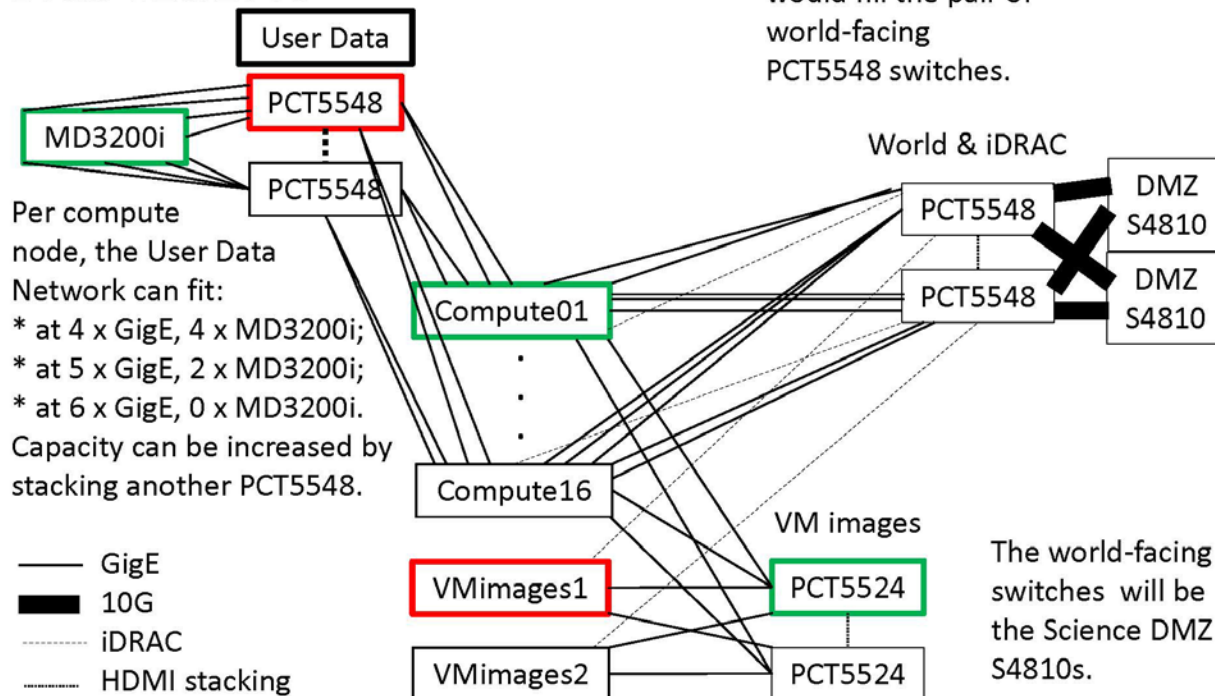
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OURcloud

OU Research Cloud (virtualized server pool) Draft 4/23/2013

5 x GigE + 1 x iDRAC
per compute node
would fill the pair of
world-facing
PCT5548 switches.



Oklahoma PetaStore

A large scale tape library, available to researchers at OU (and statewide), with a unique business model that makes long term archival storage affordable.

OURRstore, the PetaStore's successor, is coming soon!



OSCER Personnel

- Director: Henry Neeman
- Senior System Administrator: Dave Akin
- Petascale Storage Administrator: Patrick Calhoun
- System Administrators: Kali McLennan, Jason Speckman
- Research Computing Facilitator, Associate Director for Remote & Heterogeneous Computing: Horst Severini
- Research Computing Facilitator: Jim Ferguson



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Upcoming Resources

New Supercomputer: RFP

- We can't say much about the new supercomputer RFP, because information is embargoed until the RFP process is completed.
- We'll make an announcement when the time comes.
- Our research stakeholders will be happy!



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New Supercomputer: Changes

- **Rolling purchases** instead of leasing: no “forklift upgrade.”
- **Retain old hardware longer**: We plan to have all of Schooner’s IT-owned compute nodes (Haswell, Broadwell) in production through ~2024.
 - **Condominium hardware**: The supercomputer you bought it for, plus the next supercomputer.
 - Schooner Haswell, Broadwell and Xeon Phi: through ~2024 (Schooner + Sooner).
 - Schooner Skylake, Cascade Lake and Rome: through ~2028 (Schooner + Sooner + Boomer).
- Ceph for home and slow scratch directories.
 - More on this shortly.



New Supercomputer: Features

- Updated networks (Infiniband and Ethernet).
- AI/Machine Learning
 - More hardware capacity
 - More variety of hardware components
 - More emphasis on AI/ML instead of floating point
- Auto-archive directory for each user in each filesystem
 - Example: /scratch/hneeman/autoarchive
 - A daemon script will constantly walk the filesystems looking for new/modified files to archive.
 - We'll make this capability available to other institutions that use OURRstore (more on this shortly).



OURdisk (Ceph Condominium)

- OU Research Disk (OURdisk)
- Pricing coming soon – will be the lowest cost disk offering in OU IT history!
- Ceph clusters at OU Norman and OUHSC
 - ~3.8 PB per campus to start, then add more with demand
 - 8+3 erasure coding – more reliable than RAID6!
 - We wrote a simulator that showed 0.1% chance of 3 simultaneous drive failures on 1000+ drives over 5 years.
- Being deployed now (physical deployment completed).
- Initially available on the supercomputer, then we'll roll out more options gradually, such as:
 - mirroring between campuses (at double the price);
 - mount on other OU IT servers;
 - mount on non-IT servers.



OURRstore Tape Archive

- OU & Regional Research Store
- Continues our successful business model on the PetaStore:
 - NSF MRI buys HW/SW;
 - CIO covers space/power/cooling/network/labor/maintenance;
 - researchers buy tape cartridges.
- Open to researchers in all EPSCoR jurisdictions and all Great Plains Network full member states.
- Institutions in non-EPSCoR/non-GPN jurisdictions can buy a tape cartridge expansion cabinet (we have room for 2).
- Over 80 research teams waiting (im)patiently.
- Initially, $6 \times$ LTO-8 tape drives =
- ~11,000 tape cartridge slots now, can grow to ~16,000.



OURRstore Status

- All hardware purchased and delivered to OU's 4PP data center.
- Tape library physical deployment done.
- Disk, server, switch physical deployment coming shortly.
- “Friendly user” mode late 2020, full production spring 2021.
 - “Friendly user” means the exact opposite of user friendly.
- Once we're in production, we'll set the PetaStore to read-only, then start copying files from there to here.
 - Copying will take at least 4 months, probably 6-12 months.



OURRstore New Features

- **Auto-Archiving**: User places files in a specific directory, a daemon process archives them automatically.
- **File Sharing** (via Globus license): With a few clicks, a file owner can designate a file to be downloadable by (a) a specific user, (b) a specific group or (c) the whole world. (Files are private by default.)
- **Caching**: Files live on the disk front end until they're the least recently used and need to be cleared out to make room for incoming files – popular files are on disk and tape, unpopular files are on tape only.
- **Disk Purchase**: Buy disk that files can live on permanently, for fast downloading.
- **Researcher Cost**: LTO-7 “Type M” is 3.6 times bigger, half the cost per TB of LTO-6 on the PetaStore.



HIPAA Enclaves

- All OSCER systems will have HIPAA enclaves, targeting calendar 2021 (in planning stages now).
 - Supercomputer HIPAA enclave
 - OURdisk (Ceph) HIPAA enclave
 - OURRstore HIPAA enclave
- Later, we plan to expand to other flavors of regulated data (e.g., Controlled Unclassified Information).



Accomplishments



OSCER Outcomes: Research

- External research funding to OK institutions facilitated by OneOCII lead institutions (Fall 2001- Summer 2013): **\$375M+**
- Funded projects facilitated: **600+**
- OK faculty and staff: **250+** in **30+** academic disciplines
- Specifically needed OneOCII just to be funded: **~\$45M**
(necessary but far from sufficient)
 - NSF EPSCoR RII Track-1 (2008-13, OU+OSU): \$15M
 - NSF EPSCoR RII Track-1 (2013-18, OU+OSU+Noble)): \$20M
 - NSF EPSCoR RII Track-2 (OU+OSU+KU+KSU): \$6M (\$3M to OU+OSU)
 - NSF EPSCoR RII C2 (OU+OSU+TU+LU+Noble+OneNet): \$1.17M
 - NSF CC-NIE (OU+OSU+LU+OII+UCO+OneNet): \$500K
 - NSF CC*IIE (OU): \$400K
 - NSF CC*IIE (OneNet+GPN): \$350K
 - **NSF CC* (ORU/CU/ECU): \$500K**
 - NSF MRI (OU): \$968K
 - NSF MRI (OU): \$793K
 - NSF MRI (OSU): \$908K
 - NSF MRI (OSU): \$950K
 - NSF MRI (Langston U): \$250K
 - NSF MRI (UCO): \$304K
 - NSF MRI (TU): \$180K
 - DOD DURIP (TU): \$200K
 - NSF CC* (NSU/SWOSU/SE/RSU): \$334K
- Publications facilitated: **2900+**



OSCER Outcomes: Education #1

- Courses at OU
 - Ricardo Betancur, Biology
 - Sudarshan Dhall, Computer Science – multiple times
 - Andy Fagg, Computer Science – multiple times
 - Paul Huang, Chemical, Biological & Materials Engineering
 - Amy McGovern, Computer Science
 - Chongle Pan, Computer Science
 - Tyler Ransom, Economics
 - Ming Xue, Meteorology – multiple times



OSCER Outcomes: Education #2

Teaching: 10 institutions including 3 MSIs

- Taught parallel computing using OSCER resources:
 - Cameron U – multiple times
 - East Central U (NASNI) – multiple times
 - Oklahoma City U – multiple times
 - Southeastern Oklahoma State U (NASNI) – 3 semester sequence, multiple times
- Taught computational chemistry using OSCER resources:
 - Northeastern State U (NASNI) – multiple times
 - Southern Nazarene U
 - Rogers State U – multiple times
- Taught Bioinformatics using OSCER resources:
 - U Tulsa – 2 semester sequence



OneOCII CI Grants

COMPLETED

1. Grant No. EPS-0919466, "A cyberCommons for Ecological Forecasting," OU+OSU+KU+KSU, \$6M
2. Grant No. EPS-1006919, "Oklahoma Optical Initiative," OU+OSU+Noble+TU+LU+OneNet, \$1.17M
3. Grant No. OCI-10310029, "MRI: Acquisition of Extensible Petascale Storage for Data Intensive Research," OU, \$793K
4. Grant No. OCI-1126330, "Acquisition of a High Performance Compute Cluster for Multidisciplinary Research," OSU, \$908K
5. Grant No. ACI-1229107, "Acquisition of a High Performance Computing Cluster for Research and Education," LU, \$250
6. Grant No. ACI-1440774, "ENCITE: ENabling CyberInfrastructure via Training and Engagement," OneNet+GPN, \$130K
7. Grant No. ACI-1341028, "OneOklahoma Friction Free Network," OU+OSU+LU+OII+UCO+OneNet, \$500K
8. Grant No. ACI-1440783, "A Model for Advanced Cyberinfrastructure Research and Education Facilitators," OU, \$400K
9. Grant No. ACI-1429702, "MRI: Acquisition of a High Performance Computing Cluster for Research at a Predominantly Undergraduate Institution," UCO, \$304K
10. Grant No. ACI-1531128, "MRI: Acquisition of Shared High Performance Compute Cluster for Multidisciplinary Computational and Data-Intensive Research," OSU, \$950K
11. Grant No. ?, "DURIP-ARO: Heterogeneous Cluster for Cyber-Physical System Security Analytics," TU, \$200K
12. Grant No. CNS-1531270, "MRI: Development of Heterogeneous Cluster for Cyber-Physical System Hybrid Analytics," TU, \$180K
13. Grant No. OAC-1659235, "CC* Network Design: Multiple Organization Regional One Oklahoma Friction Free Network (MORe OFFN)", NSU+SWOSU+SE+RSU, \$334K

ONGOING

1. Grant No. OAC-1828567, "MRI: Acquisition of a Regional Resource for Long-term Archiving of Large Scale Research Data Collections," OU, \$968K
2. Grant No. OAC-1925744, "CC* Regional: Extended Vital Education Reach Multiple Organization Regional OneOklahoma Friction Free Network (EVER-MORe-OFFN)," ORU+Cameron+ECU, \$500K
3. Grant No. OAC-1925681, "CC* Team: Great Plains Regional CyberTeam," \$950K (OU subaward \$127K) – all of GPN

TOTAL to OK under OCII/OneOCII: Sep 2008-Sep 2020:

\$13.7M in 16 CI grants to 15 OK institutions (OU, OSU, TU, LU, UCO, OII, Noble, OneNet, CU, ECU, NSU, ORU, SWOSU, SE, RSU)

Average of \$1.1M per year in new CI grants to OK institutions

Comparison: 2001-2008: \$722K (3 grants) TOTAL (1/12 as much per year)



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Grants That Needed OCII/OneOCII

COMPLETED

- Grant No. EPS-0814361, “Building Oklahoma's Leadership Role in Cellulosic Bioenergy,” OU+OSU, \$15M
- Grant No. EPS-1301789, “Adapting Socio-ecological Systems to Increased Climate Variability,” OU+OSU+TU+Noble, \$20M

TOTAL under OCII/OneOCII: \$35M in 2 grants that needed OCII/OneOCII to be fundable, to 4 OK institutions since Sep 2008



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Papers About Pieces of/by OneOCII #1

1. H. Neeman, D. Akin, H. Al-Azzawi, K. L. Brandt, J. Brooks Kieffer, D. Brunson, D. Colbry, S. Gesing, A. Klimaszewski-Patterson, C. Mizumoto, J. A. Pine-Thomas, A. Z. Schwartz, H. Severini, D. Voss and M. Tanash, 2020: “Cyberinfrastructure Facilitation Skills Training via the Virtual Residency Program.” *Proc. PEARC’20*, 421-428. DOI: [10.1145/3311790.3396629](https://doi.org/10.1145/3311790.3396629).
2. S. P. Calhoun, D. Akin, B. Zimmerman and H. Neeman, 2019: “Large Scale Research Data Archiving: Training for an Inconvenient Technology.” *Journal of Computational Science*, 36, article 100523 (available online 2016). DOI: [10.1016/j.jocs.2020.07.005](https://doi.org/10.1016/j.jocs.2020.07.005).
3. H. Neeman, H. M. Al-Azzawi, D. Brunson, W. Burke, D. Colbry, J. T. Falgout, J. W. Ferguson, S. Gesing, J. Gyllinsky, C. S. Simmons, J. L. Simms, M. Tanash, D. Voss, J. Wells and S. Yockel, 2020: “Cultivating the Cyberinfrastructure Workforce via an Intermediate/Advanced Virtual Residency Workshop.” *Proc. PEARC’19*, article 79. DOI: [10.1145/3332186.3332204](https://doi.org/10.1145/3332186.3332204).
4. N. Berente, S. Ahalt, J. Bottum, D. Brunson, J. Cutcher-Gershenfeld, J. Howison, J. L. King, H. Neeman, J. Towns, N. Wilkins-Diehr and S. Winter, 2020: “The Professionalization of Cyberinfrastructure Personnel?” *Proc. PEARC’19*, article 87. DOI: [10.1145/3332186.3332225](https://doi.org/10.1145/3332186.3332225). **Best Paper, Workforce Development and Diversity Track.**
5. M. Brazil, D. Brunson, A. Culich, L. DeStefano, D. Jennewein, T. Jolley, T. Middelkoop, H. Neeman, L. Rivera, J. Smith and J. Wernert, 2020: “Campus Champions: Building and Sustaining a Thriving Community of Practice Around Research Computing and Data.” *Proc. PEARC’19*, article 78. [10.1145/3332186.3332200](https://doi.org/10.1145/3332186.3332200).
6. H. Neeman, H. M. Al-Azzawi, A. Bergstrom, Z. K. Braiterman, D. Brunson, D. Colbry, E. Colmenares, A. N. Fuller, S. Gesing, M. Kalyvaki, C. Mizumoto, J. Park, A. Z. Schwartz, J. L. Simms and R. Vania, 2018: “Progress Update on the Development and Implementation of the Advanced Cyberinfrastructure Research & Education Facilitators Virtual Residency Program.” *Proc. PEARC’18*, paper 71. DOI: [10.1145/3219104.3219117](https://doi.org/10.1145/3219104.3219117).



Papers About Pieces of/by OneOCII #2

7. D. Akin, M. Belgin, T. A. Bouvet, N. C. Bright, S. Harrell, B. Haymore, M. Jennings, R. Knepper, D. LaPine, F. C. Liu, A. Maji, H. Neeman, R. Reynolds, A. H. Sherman, M. Showerman, J. Tillotson, J. Towns, G. Turner and B. Zimmerman, 2017: “Linux Clusters Institute Workshops: Building the HPC and Research Computing Systems Professionals Workforce.” *HPCSYSPROS'17: Proc. HPC Systems Professionals Workshop 2017*, article 4. DOI: [10.1145/3155105.3155108](https://doi.org/10.1145/3155105.3155108).
8. H. Neeman, A. Bergstrom, D. Brunson, C. Ganote, Z. Gray, B. Guilfoos, R. Kalescky, E. Lemley, B. G. Moore, S. K. Ramadugu, A. Romanella, J. Rush, A. H. Sherman, B. Stengel and D. Voss, 2016: “The Advanced Cyberinfrastructure Research and Education Facilitators Virtual Residency: Toward a National Cyberinfrastructure Workforce.” *Proc. XSEDE'16*, article 57. DOI: [10.1145/2949550.2949584](https://doi.org/10.1145/2949550.2949584).
9. H. Neeman, K. Adams, J. Alexander, D. Brunson, S. P. Calhoun, J. Deaton, F. Fondjo Fotou, K. Frinkle, Z. Gray, E. Lemley, G. Louthan, G. Monaco, M. Morris, J. Snow and B. Zimmerman, 2015: “On Fostering a Culture of Research Cyberinfrastructure Grant Proposals within a Community of Service Providers in an EPSCoR State.” *Proc. XSEDE'15*, article 19. DOI: [10.1145/2792745.2792764](https://doi.org/10.1145/2792745.2792764).
10. H. Neeman, D. Akin, J. Alexander, D. Brunson, S. P. Calhoun, J. Deaton, F. Fondjo Fotou, B. George, D. Gentis, Z. Gray, E. Huebsch, G. Louthan, M. Runion, J. Snow and B. Zimmerman, 2014: “The OneOklahoma Friction Free Network: Towards a Multi-Institutional Science DMZ in an EPSCoR State.” *Proc. XSEDE'14*, article 49. DOI: [10.1145/2616498.2616542](https://doi.org/10.1145/2616498.2616542).
11. S. P. Calhoun, D. Akin, J. Alexander, B. Zimmerman, F. Keller, B. George and H. Neeman, 2014: “The Oklahoma PetaStore: A Business Model for Big Data on a Small Budget.” *Proc. XSEDE'14*, article 48. DOI: [10.1145/2616498.2616548](https://doi.org/10.1145/2616498.2616548).
12. C. Carley, B. McKinney, L. Sells, C. Zhao and H. Neeman, 2013: “Using a Shared, Remote Cluster for Teaching HPC.” *Proc. IEEE CLUSTER 2013*. DOI: [10.1109/CLUSTER.2013.6702630](https://doi.org/10.1109/CLUSTER.2013.6702630).



Papers About Pieces of/by OneOCII #3

13. H. Neeman, D. Brunson, J. Deaton, Z. Gray, E. Huebsch, D. Gentis and D. Horton, 2013: “The Oklahoma Cyberinfrastructure Initiative.” *Proc. XSEDE’13*, article 70. DOI: [10.1145/2484762.2484793](https://doi.org/10.1145/2484762.2484793).
14. A. Fitz Gibbon, P. Gray, D. A. Joiner, T. Murphy, H. Neeman, R. M. Panoff, C. Peck and S. Thompson, 2010: “Teaching High Performance Computing to Undergraduate Faculty and Undergraduate Students.” *Proc. TeraGrid’10*, article 7. DOI: [10.1145/1838574.1838581](https://doi.org/10.1145/1838574.1838581). **Best Paper: Education, Outreach & Training Track.**
15. H. Neeman, H. Severini, D. Wu and K. Kantardjieff, 2010: “Teaching High Performance Computing via Videoconferencing.” *ACM Inroads*, 1 (1), 67-71. DOI: [10.1145/1721933.1721954](https://doi.org/10.1145/1721933.1721954).
16. H. Neeman, H. Severini, D. Wu and K. Kantardjieff, 2008: “Teaching Supercomputing via Videoconferencing.” *Proc. TeraGrid 2008*. **Best Paper: Education, Outreach & Training Track.**
17. H. Neeman, H. Severini and D. Wu, 2008: “Supercomputing in Plain English: Teaching Cyberinfrastructure to Computing Novices.” *inroads: SIGCSE Bulletin*, 40 (2), 27-30. DOI: [10.1145/1383602.1383628](https://doi.org/10.1145/1383602.1383628).



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HPC Capacity

- 2002: 1.2 TFLOPs statewide, 1 Service Provider
- 2005: 6.5 TFLOPs statewide, 1 Service Provider
- 2008: 40 TFLOPs statewide, 2 Service Providers
- 2012: 200+ TFLOPs statewide, 4 Service Providers
- 2015: 400+ TFLOPs statewide, 5 Service Providers
- 2016: 400+ TFLOPs statewide, 6 Service Providers
- 2018: 500+ TFLOPs statewide, 5 Service Providers
- **2020: 800+ TFLOPs statewide, 6 Service Providers**
 - OU, OSU, TU, Langston U, UCO, ORU

This modestly beats Moore's Law (~700x vs 512x).



External Funding Summary

- External research funding facilitated by OSCER
(Fall 2001- Fall 2020): **\$824M total, \$375M to OU** (46%)
- Funded projects: **680+**
- **260+** OU faculty and staff in **36** academic departments and **13** non-academic units
- Comparison: Fiscal Year 2002-20 (July 2001 – June 2020):
OU Norman externally funded research expenditure: \$1.74B

Since being founded in fall of 2001,
OSCER has enabled research projects comprising
over 1 / 5 of OU Norman's total externally funded research expenditure, with more than a **10-to-1 return on investment**.



External Research Grants

1. A. McGovern et al, "AI Institute: Artificial Intelligence Institute for Environmental Sciences (AI2ES)," NSF, \$20M
2. J. Zhou, "Searching for General Rules Governing Microbiome Dynamics Using Anaerobic Digesters as Model Systems," NSF, \$3M
3. A. Pereira, "Systems Genetics Studies on Rice Genomes for Analysis of Grain Yield and Quality Under Heat Stress," NSF, \$2.5M
4. D. Devegowda, C. Sondergeld, C. Rai, "Reservoir Characterization in Unconventional Oil & Gas Reservoirs," Marathon Oil, \$2M
5. S. Crossley, L. Lobban, B. Wang, A. Feltz, "EFRI E3P: Tuning Catalyst Design to Recycle Mixed Polymer Streams," NSF, \$2M
6. S. Welch, "Building Field-Based Ecophysiological Genome-to-Phenome Prediction," NSF, \$2M
7. L. Bartley, Stacey, Thelen, Du, "Genome-enabled characterization of orphan receptor-like kinases in plants," NSF, \$2M
8. D. Devegowda, F. Civan, R. Sigal, "Simulation of Shale Gas Reservoirs Incorporating Appropriate Pore Geometry and the Correct Physics of Capillarity and Fluid Transport," RPSEA, \$1.4M
9. Y. Shao, "Multiscale Modeling of Enzymatic Reactions and Firefly Bioluminescence," NIH, \$1M
10. R. Palmer, B. Cheong, C. Fulton, J. Salarzar, H. Sigmarsson, M. Yeary, T.-Y. Yu, G. Zhang, "ARRC R&D Activities in Phased Array Weather Radar," NOAA, \$1.1M
11. E. Martin, "CAREER: Precipitation Variability Across Timescales," NSF, \$940K
12. P. Fritsch, "American Crossroads: Digitizing the Vascular Flora of the South-Central United States," NSF, \$934K
13. R. McPherson, E. Kuster, E. Martin, B. Moore, M. Shafer, "Hosting the Department of the Interior's South Central Climate Adaptation Science Center," USGS, \$896K
14. M. Elshahed, "PurSUIt: Discovery, characterization, and elucidation of the global patterns and determinants of anaerobic fungal (Neocallimastigomycota) diversity in the herbivorous gut," NSF, \$762K
15. G. McFarquhar, W. Wu, X. Hu, "Use of MARCUS, MICRE and COMBLE data to enhance understanding of cloud and aerosol processes in their interactions in high-latitude regions," DOE, \$690K
16. D. Resasco, B. Wang, "Hydrophobic enclosures in bio-inspired nanoreactors for enhanced phase selectivity. A combined experimental/theoretical approach," DOE, \$675K

OSCER-FACILITATED FUNDING TO DATE:

\$824M total, \$375M to OU



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OneOklahoma Cyberinfrastructure Initiative

External Research Grants (cont'd)

17. G. McFarquhar, "Experiment of Sea Breeze Convection, Aerosols, Precipitation and Environment (ESCAPE)," NSF, \$605K
18. A. Holgado, "RUI: Examining Molecular Players Integrating Autophagy and Neuronal Development and Maintenance," NSF, \$600K
19. D. Devegowda, C. Sondergeld, C. Rai, "Unconventional Shale Consortium," Industry Consortium, \$600K
20. N. Youssef, "BEE: Discovery and characterization of novel microbial lineages in an early Earth analog sulfur-based ecosystem," NSF, \$578K
21. H. Bluestein, B. L. Cheong, D. Bodine, "Enhanced Radar Studies of Severe Convective Storms and Tornadoes," NSF, \$576K
22. D. Devegowda, C. Sondergeld, C. Rai, "Enhanced Oil Recovery in Shales," Ovintiv Corp, \$500K
23. E. Baron, "Modeling the Atmosphere of Solar and Other Stars: Radiative Transfer with phxT," NASA, \$478K
24. X. Wang, "Advancing the Direct Assimilation of Radar Observations to Improve Convective Scale Numerical Weather Prediction through Optimizing Combined Use of Static and Ensemble Covariances, the Additive Perturbations, and the Assimilation Frequency in the Hybrid E," NOAA, \$523K
25. B. Schenkel, N. Yussouf, "Investigating the impact of ambient deep-tropospheric vertical wind shear on tornadoes and their attendant supercells within tropical cyclones," NSF, \$499K
26. A. Johnson, X. Wang, "Flow-dependent machine learning based post-processing of convection allowing ensembles to provide convective outlooks of severe weather hazards," NOAA, \$489K
27. K. Leighly, D. Terndrup, "Spectral Synthesis for Broad Absorption Line Quasars – Feedback and Physics for Everyone," NSF, \$474K
28. A. Ford Versypt, "CAREER: Multiscale Modeling of a Virtual Kidney during the Onset and Progression of Diabetic Kidney Disease," NSF, \$459K
29. P. Zhu, "CAREER: Lead-Free Pseudohalide/Halide Perovskite Nanocrystals for White Light-Emitting Diodes," NSF, \$440K
30. D. Devegowda, F. Civan, R. Sigal, "Simulation of Shale Gas Reservoirs Incorporating Appropriate Pore Geometry and the Correct Physics of Capillarity and Fluid Transport," Industry Consortium, \$405K
31. D. Arcila, "Exploring the genomics of convergent snout elongations in deep-sea fishes," NSF, \$300K
32. K. Nicholas, "SusChEM: Deoxygenation and Reductive Coupling of Alcohols Catalyzed by Oxo-Metal Complexes," NSF, \$405K

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External Research Grants (cont'd)

33. Y. Jung, C. Liu, M. Xue, "Development and Testing of a GSI-based Multi-Scale EnKF System for Convection-Allowing Stand-Alone Regional FV3," NOAA, \$402K
34. Y. Kuang, "RoL: The rules of life were made to be broken - Connecting physiology, evolutionary ecology, and mathematics to identify a Growth Rate Rule," NSF, \$396K
35. N. Youssef, "Phylogenomics and evolutionary history of the anaerobic fungal group, Neocallimastigomycota," NSF, \$393K
36. K. Hambright, "Challenging the broadcast allelopathy paradigm in toxigenic microbial eukaryotic ecology," NSF, \$385K
37. N. Snook, C. Homeyer, A. McGovern, "0-3 Hour Tornado Prediction using the Warn on Forecast System and Machine Learning," NOAA, \$363K
38. D. Andresen et al, "GP-ARGO: The Great Plains Augmented Regional Gateway to the Open Science Grid," NSF, \$357K
39. W. Wu, G. McFarquhar, "From Clouds to Precipitation: Multiscale Dynamics-Microphysics Interactions in Cumulus Clouds," DOE, \$344K
40. A. McGovern, "Deep learning for operational identification and prediction of synoptic-scale fronts," NOAA, \$334K
41. M. Fishbein, "Can Hundreds of Unlinked Loci Really Resolve Recent, Rapid Radiations of Plant Species?," NSF, \$304K
42. C. Homeyer, A. McGovern, "Automated Detection and Analysis of Severe, Tropopause-Penetrating Convective Storm Patterns Using Remote Sensing Data Fusion and Deep Learning," NASA, \$325K
43. P. D. Sheehan, "Demographics of the Youngest Protostars and their Disks," NSF, \$300K
44. M. Xue, X. Hu, N. Snook, T. Supinie, "Unified Forecast System Research-to-Operations Project (UFS-R20) Task: RRFS and Retirement of Legacy Models," NOAA, \$292K
45. M. Biggerstaff, K. Elmore, "Understanding the Propagation and Evolution of Rotation in Linear Storms," NOAA, \$259K
46. X. Wang, "Accelerate the development of the Hurricane Analysis and Forecasting System (HAFS)," NOAA, \$250K
47. D. Bodine, B. L. Cheong, T. Y. Yu, R. Palmer, A. Reinhart, P. E. Kirstetter, "Using Observations, Simulations, and Artificial Intelligence to Develop a Lake-Effect Snow Prediction System," Weathernews Americas, \$249K
48. X. Wang, A. Johnson, "UFS-R20 CAM Sub-Project: Rapid Refresh Forecast System (RRFS) development and implementation," NOAA, \$244K

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External Research Grants (cont'd)

49. J. Walter, B. Carpenter, "Refining principal stress measurements in reservoir underburden in regions of induced seismicity through seismological tools, laboratory experiments, and theory," Electric Power Research Institute Inc, \$233K
50. M. Xue, C. Liu, N. Snook, "Advanced Data Assimilation and Prediction Research for Convective-Scale 'Warn-on-Forecast'," NOAA, \$200K
51. P. Zhu, "CAREER: Lead-Free Pseudohalide/Halide Perovskites for Next-Generation White Light-Emitting Diodes," NSF, \$225K
52. F. Kong, M. Xue, "Development of a Storm-Scale Ensemble Numerical Weather Prediction System for Chongqing Meteorological Service," Chinese Acad Sci, \$199K
53. R. Nygaard, "Real-Time Drilling Optimization System for Improved Overall Rate of Penetration and Reduced Cost/Ft in Geothermal Drilling," Oklahoma State U, \$187K
54. E. Baron, "Unlocking Type Ia Supernovae with an Ultraviolet Key," NASA, \$181K
55. P. Gignac, "Ecomorphological diversification and the origin of phenotypic disparity in crocodile-line archosaurs," NSF, \$161K
56. T. Misiewicz, A. Moore, "NSF Postdoctoral Fellowship in Biology FY 2018," NSF, \$138K
57. J. Basara, "19-EARTH19-321, Evaluating the Contributions of Local and Non-Local Land Atmosphere Coupling to Flash Drought Evolution and Prediction," NASA, \$135K
58. B. Mooers, "Role of a Lysine Hydroxylase in Breast Cancer," OCAST, \$135K
59. Q. Xu, "Advance the Cutting-Edge Science and Technology in Radar and Satellite Data Assimilation for Analyses and Predictions of Severe Storms and Tropical Cyclones," DOD ONR, \$124K
60. E. Maher, D. Horm, "OKFutures Systems-Level Evaluation Planning Oklahoma Partnership for School Readiness," OKFutures, \$112K
61. D. Devegowda, "Factors Governing Diffusiophoresis and its Impact on Fluid Flow in Porous Media," American Chemical Society, \$110K
62. X. Wang, Y. Wang, "Development and Research of Hybrid EnVar Data Assimilation for Convective-Scale," NOAA, \$100K
63. R. Nygaard, "Advanced cement characterization and modeling to evaluate novel additives to improve wellbore integrity," Oklahoma State U, \$100K
64. P. Kotlik, S. Markova, H. Lanier, "Genomics of adaptation along a latitudinal cline: Bank vole genome sequencing collaboration," Czech Academy of Science \$90K

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External Research Grants (cont'd)

65. K. Brewster, F. Carr, N. Snook, "CASA DFW Testbed Operations and Data Impacts," Synoptics, \$89K
66. F. Kong, X. Hu, "Development of a Storm-Scale Ensemble Numerical Weather Prediction System for Chongqing Meteorological Service," Chinese Acad Sci, \$87K
67. X. Dai, "Microlensing Size of AGN Reflection Hump," NASA, \$73K
68. J. Pei, "Improving the Modeling Fidelity of Complex Aerospace Systems with Mem-Models," Oklahoma State U, \$27K
69. S. Schroeder, "Modulation of the human lung transcriptomic immune response by SARS-CoV-2 M protein," Presbyterian Health Fndtn, \$25K
70. S. Schroeder, "Viral RNA Structures, Function, and Energetics," NIH, \$25K
71. P. D. Sheehan, "Surrogate Modeling of Protostellar Disk Radiative Transfer Models," NRAO, \$10K
72. P. Brown, C. Ashall, E. Baron, A. Cikota, L. Galbany, P. Hoeflich, D. Howell, P. Milne, N. Suntzeff, L. Wang, X. Wang, Y. Yang, J. Zhang, "Ultraviolet Spectroscopy of Extreme Standard Candles, 2020-2022, 62 Orbits," NASA, \$?

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External Research Grants (cont'd)

73. A.T. Peterson (KU), X. Xiao, J. Basara, R. Jabrzemski, H. Neeman, S. Little (OSU), R. Brennan (UCO), F. Agosto (KU), R. Raghavan (KSU), A. Ghosh (PSU), A. Khalighifar (KU), "RII Track-2 FEC: Marshalling Diverse Big Data Streams to Understand Complexity of Tick-borne Diseases in the Southern Great Plains," NSF, \$3.9M (total), \$883K (OU)
74. L. Xiang, "Academic-Industry Partnership for the Translation of a 4D in vivo Dosimetry Approach for Radiation Therapy," NIH, \$3.8M
75. X. Xiao, D. Prosser (USGS), R. Webby (St. Jude Children's), Yuanwei Qin, "US-China Collab: Harnessing big data to understand and predict diversity and transmission of human- and animal-infected avian influenza viruses in China," NSF, \$2.5M (total), \$2M (OU)
76. P. Gaffney (OMRF), B. McKinney (TU), "Molecular Mechanisms and Genetics of Autoimmunity," NIH, \$2.4M
77. K. D. Hambright, L. Krumholz, A. Wilson (Auburn U), H. Paerl (UNC Chapel Hill), M. Steffen (James Madison U), "Dimensions: Collaborative research: The cyanobacterial bloom microbial interactome as a model for understanding biogeographical and seasonal patterns in functional biodiversity," NSF, \$2M
78. M. Paulus (LIBR), B. McKinney (TU), "The Center for Neuroscience-based Mental Health Assessment and Prediction (NEUROMAP)," NIH, \$1.49M
79. R. McPherson, E. Kuster, E. Martin, B. Moore, M. Shafer, "Hosting the Department of the Interior's South Central Climate Adaptation Science Center," USDOJ/USGS, \$870K
80. G. McFarquhar, R. Rauber (UIUC), "SOCRATES: Microphysical processes in Southern Ocean Clouds," NSF, \$821K (total), \$367K (OU)
81. D. K. Walters, "Implementation and Validation of Advanced Turbulence Modeling Methods for Liquid Metal Flow in Nek5000," DOE, \$756K
82. K. Brewster, F. Kong, N. Snook, M. Xue, C. Zhang, "Enhancing CAM Ensemble Forecast System and Improving Ensemble Forecast Products in Support of HMT Winter Weather and Heavy Precipitation Forecasting," NOAA, \$748K
83. B. Wang, "Catalysis Driven by Confined Hot Carriers at the Liquid/Metal/Zeolite Interface," DOE, \$750K
84. M. Biggerstaff, "Spatiotemporal maps of damaging winds from integrated remote and in situ observations," NIST, \$737K
85. C. Pan, "Integrating single-cell wetland microbiome structure, function, and activity to ecosystem-scale biogeochemical fluxes," DOE, \$637K

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External Research Grants (cont'd)

86. G. McFarquhar, W. Wu, R. Rauber (UIUC), "Collaborative Research: Impacts of microphysical, thermodynamic, and dynamical processes on nocturnal and oceanic convective systems via analyses from PECAN and HAIC/HIWC," NSF, \$549K
87. N. Yussouf, P. Heinselman, L. J. Wicker, Y. Jung, M. Xue, "Impact of Assimilating Phased Array Radar Observations on Convective-scale Numerical Weather Prediction Model for Severe Weather Forecasts, Spectrum Efficient National Surveillance Radar (SENSR) research as part of 2015 Spectrum Pipeline Act," ?, \$544K
88. G. Richter-Addo, "Chemical Reactivity and Redox Behavior of Heme-HNO_x Derivatives," NSF, \$540K
89. M. Xue, C. Ziegler, X. Hu, "Collaborative Research: Observing and Understanding PBL Heterogeneities and Their Impacts on Tornadoic Storms During VORTEX-SE 2018 Field Experiment," NSF, \$524K
90. N. Kaib, "CAREER: Next Generation Models of Planet Formation and Evolution," NSF, \$521K
91. J. Garg, "Investigation of strain and superior functionalization schemes for large enhancement of thermal conductivity in polymer-graphene nanocomposites and binary semiconductors," NSF, \$500K
92. S. Razavi, D. Papavassiliou, "Effect of heterogeneous particles and surfactants on the stability and rheology of fluid interfaces," NSF, \$500K
93. S. Razavi, D. Papavassiliou, "Effect of heterogeneous particles and surfactants on the stability and rheology of fluid interfaces," NSF, \$500K
94. R. Voronov (NJIT), "Developing New Tissue Engineering Technology for Bone Implants," Gustavus and Louise Pfeiffer Research Foundation, \$400K
95. Y. Jung, M. Xue, C. Liu, F. Kong, "Accelerated Implementation, Testing and Evaluation of Optimized Radar Data Assimilation Capabilities within Ensemble-Variational Hybrid GSI for the NOAA Convection-allowing rapidly updated Forecasting System," NOAA, \$394K
96. M. Galizia, B. Wang, "Collaborative Research: Molecular-level understanding of small molecule transport in glassy polymers exhibiting configurational free volume," NSF, \$391K
97. G. McFarquhar, R. Marchand (UW), "Quality control and analysis enabling use of MARCUS and MICRE data for scientific purposes," DOE, \$390K
98. X. Wang, "Accelerate FV3-based ensemble prediction system: Hourly Updating CAM Ensemble Development," NOAA, \$383K
99. X. Wang, "MPAR targeting observation research for WoF," NOAA, \$362K
100. N. Kaib, "Planetary Systems as the Bottom Levels of Hierarchies," NASA, \$345K

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External Research Grants (cont'd)

101. D. Papavassiliou, "Turbulent transport in wall turbulence: The role of VLSMs and the interplay of molecular/convective effects," NSF, \$325K
102. Wu, "Collaborative Proposal: Observational and Numerical Modeling Studies of Rain Microphysics," NSF, \$318K
103. K. D. Hambright, J. Beyer, "Challenging the broadcast allelopathy paradigm in toxigenic microbial eukaryotic ecology," NSF, \$300K
104. M. Xue, X. Hu, Y. Jung, K. Brewster, "Evaluation and Optimization of Two New Scale-Aware PBL Schemes within WRF for the Prediction of Day- and Night-Time Storm Environment and Tornadoic Storms during VORTEX-SE," NOAA, \$287K
105. R. Betancur, "Collaborative Research: FishLife: genealogy and traits of living and fossil vertebrates that never left the water," NSF, \$273K
106. B. Moore, K. Brewster, F. Carr, "CASA DFW Testbed Operations and Data Impacts," SGT & EarthNetworks, \$260K
107. G. McFarquhar, "Observations of aerosols above clouds and their interactions (ORACLES)," NASA, \$249K
108. D. K. Walters, "Robust Adaptive Controls for Shipboard Landing of Multi-Rotor Unmanned Aerial Vehicles," DoD ONR, \$243K
109. X. Wang, "Improving National Weather Service Convection Allowing Hazardous Weather Prediction by Using a Cost-Effective Large Background Ensemble in a Regional FV3 EnVar Data Assimilation System," NOAA, \$462K
110. F. Kong, X. Hu, M. Xue, K. Brewster, "Development of a Storm-Scale Ensemble Numerical Weather Prediction System for Chongqing," Chongqing Inst of Green and Intelligent Tech, Chinese Academy of Sciences, \$225K
111. X. Chen, "Collaborative Research: Multi-scale validation of earthquake source parameters to resolve any spatial, temporal or magnitude-dependent variability at Parkfield, CA," NSF, \$224K
112. F. Kong, M. Xue, Y. Jung, X. Hu, "Upgrade the Storm-Scale Assimilation and Ensemble Forecast Capability for Shenzhen Meteorological Bureau," Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, \$214K
113. L. Xiang, "Real-Time Dosimetry in External Beam Radiation Therapy with X-Ray Acoustic Computed Tomography," OK-CAST, \$209K
114. R. Janknecht, B. Mooers, "Role of JMJD4 in Breast Cancer," Presbyterian Health Foundation, \$200K

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External Research Grants (cont'd)

115. N. Yussouf, "Development of a Regional Storm-scale Ensemble Forecasting System Embedded in HWRF for Extreme Rainfall Producing Landfalling Tropical Cyclones," NOAA/OAR/NSSL \$200K
116. X. Wang, "Development of the ground-based radar observation assimilation capability within the HWRF hybrid ensemble-variational data assimilation system to improve the land-falling hurricane prediction," NOAA, \$193K
117. L. Huang, Y. Wu, L. McNeil (UNC Chapel Hill), C. Karwacki (Edgewood Chemical Biological Ctr), "Influences of Structural Design on Molecular Accessibility, Kinetics, Adsorption, and Reactivity: Degradation of CWAs by MOFs," DTRA, \$180K
118. T. Jones, P. Skinner, A. Fierro, A. Reinhart, K. Knopfmeier, "Short-term Ensemble Prediction of Tornadoes in Landfalling Tropical Cyclones," NOAA, \$163K
119. Y. Shao, "Structure Based Design of Potent and Selective Inhibitors to Pro-apoptotic Bax/Bak (Pilot project)," NIH, \$150K
120. C. Pan, "High Performance Bioinformatics Workflow for Integrative ...," U Tennessee Knoxville, \$146K
121. M. Biggerstaff, "2018 Hurricane Season RAPID Study of Hurricane Florence at Landfall," NSF, \$143K
122. X. Wang, A. Johnson, Clark, "Improving NWS Convection Allowing Hazardous Weather Ensemble Forecasts through Optimizing Multi-Scale Initial Condition (IC) Perturbations," NOAA, \$138K
123. Y. Shao, "Rational Development of Selective and Potent Inhibitors to Pro-apoptotic Bax Protein," OCAST, \$135K
124. E. Epifanosky(Q-CHEM Inc), Y Shao, "Multiscale ab initio QM/MM and machine learning methods for accelerated free energy simulations," NIH, \$132K (total), \$24K (OU)
125. N. Kaib, "(XRP18 Step-2) Planetary Systems as the Bottom Levels of Hierarchies," NASA, \$126K
126. D. Bodine, Yu, B. Cheong, A. Reinhart, R. Palmer, "Observation-based Microphysics Classification and Cloud Activity for Lake-effect Snow," Weathernews Americas, \$124K
127. D. Bodine, A. Reinhart, "Evaluation of Structural Vulnerability in the Southeast United States Using High-Resolution Tornado Simulations with Buildings and Terrain," NOAA, \$124K
128. U. Hansmann, "Role of Lipid-derived Oligomer Strains in Alzheimer Disease Phenotypes," U Southern Mississippi, \$122K

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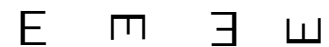


External Research Grants (cont'd)

129. C. Pan, "Identification of orthologous gene families across diverse eukaryotic genomes," UT Battelle, \$182K
130. F. Kong, M. Xue, C. Liu, "Application of Advanced Data Assimilation for Chongqing Meteorological Service," Chongqing Inst of Green and Intelligent Tech, Chinese Academy of Sciences, \$112K
131. K. Dresback, R. Kolar, "Automating River Connections Between NWM and ADCIRC – Precipitation, Lateral Inflows and Operational Strategies," NSF, \$100K
132. K. Dresback, R. Kolar, "Automating River Connections Between NWM and ADCIRC - Precipitation, Lateral Inflows and Grid Development," NOAA NSSL, \$97K
133. R. Betancur, "Collaborative Research: The role of habitat transitions in parallel marine fish radiations," NSF, \$82K
134. S. Cavallo, "Tropopause polar vortices and multi-scale Arctic predictability," DOD, \$60K
135. P. Skubic, P. Gutierrez, M. Strauss, B. Abbott, J. Stupak, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center," U Texas Arlington, \$53K
136. X. Chen, J. Walter, "Roles of stress heterogeneity and stress interaction in induced seismicity: example from the Fairview/Woodward area in Oklahoma," USGS, \$52K
137. N. Kaib, "Exploring the Evolution and Characterizing the Chaos of the Terrestrial Planets," UIUC, \$50K
138. G. McFarquhar, "Investigation of Microphysics and Precipitation for Atlantic Coastal Threatening Snowstorms (IMPACTS)," NASA, \$41K
139. L. Huang, X. Wu, "Dew Point Pressure Prediction of Natural Gas and Gas Condensation," Industry, \$36K
140. X. Chen, "Understanding the triggering process of the foreshock sequence of the 2010 M7.2 El-Mayor-Cucapah earthquake," U California Southern California Earthquake Center, \$25K
141. X. Chen, "Probing the characteristics of earthquake source complexity in areas of structural complexity," U California Southern California Earthquake Center, \$15K
142. K. Brewster, "Observing System Simulation Experiments (OSSEs) for Humidity using Cellular Network Signals," NOAA, \$9K
143. G. McFarquhar, R. Pepler, "CIMMS CA - Task II/ROC/Task I/Admin," NOAA, \$4K

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External Research Grants (cont'd)

144. H. Neeman, L. Bartley, K. Dresback, A. McGovern, H. Severini, M. Laufersweiler, "MRI: Acquisition of a Regional Resource for Long-term Archiving of Large Scale Research Data Collections," NSF, \$968K
145. S. Crowell, "The OCO-2 Model Intercomparison Project," NASA Science Team for the OCO-2 Missions, \$123K
146. A. Duerfeldt, "Hit to Lead Optimization of a Systemically Available Treatment for Diabetic Retinopathy," NIH, \$275K
147. A. West, A. Duerfeldt et al, "Structure, Function, and Therapeutic Potential of Clostridium difficile Caseinolytic Protease P," NIH, \$10.5M
148. G. Richter-Addo, "MRI: Acquisition of an X-ray Diffractometer for Research and Training in Chemical Structure-Function Studies," NSF, \$217K
149. B. Uchoa Barboza, "Interactions and quantum effects in nodal materials," NSF, \$402K
150. S. A. Shirazi, "Erosion/Corrosion Research Center (E/CRC)," Industrial, \$540K
151. S. A. Shirazi, "Tulsa University Sand Management Projects (TUSMP)," Various Oil and Gas Producers, \$150K
152. S. Schroeder, "Metal Ion Interactions in RNA Shapeshifters," Burroughs Wellcome Fund, \$9K
153. A. Duerfeldt, "Hit to Lead Optimization of a Systemically Available Treatment for Diabetic Retinopathy Major Aim: To determine structure-activity relationships of NCI8, a novel PPAR α agonist," NIH, \$422K
154. N. Snook, M. Xue, Y. Jung, A. McGovern, M. Xue, "Improving Operational Hail Prediction through Machine Learning from HREF and CAPS Storm-Scale Ensemble FV3 and WRF ARW Forecasts including Advanced Microphysics," NOAA, \$342K
155. W. Freeman, "Neuroepigenomics of Neural Stem Cell Aging.," OCASCR, \$232K
156. W. Freeman, "Sex divergence and cell specificity of age-related hippocampal DNA modifications," NIH, \$75K
157. W. Freeman, "Dynamics of the brain epigenome with aging," NIH, \$960K
158. P. Skubic, J. Stupak, B. Abbott, M. Strauss, P. Gutierrez, "Experimental Physics Investigations using the ATLAS Detector at the LHC," DOE, \$420K
159. P. Skubic, B. Abbott, J. Stupak, M. Strauss, P. Gutierrez, "University of Oklahoma High Energy Physics: Experimental Physics Investigations Using Colliding Beam Detectors at Fermilab and the Large Hadron Collider (LHC) (TASK A) 2013-2016," DOE, \$500K

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External Research Grants (cont'd)

- 160. P. Skubic, B. Abott, P. Gutierrez, M. Strauss, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center," DOE, \$115K
- 161. T. Smith, A. Reinhart, K. Ortega, K. Calhoun, "Implementing convective storm statistics from a large reanalysis of WSR-88D data for model verification and forecasting probabilistic uncertainty," NOAA, \$592K
- 162. J Gallant (Michigan State U), M. Markham (OU), Sawtell (Columbia U), Warren (Washington U St. Louis), Zakon (U Texas), "IOS EDGE: Enabling genotype-phenotype studies in weakly electric fish.," NSF, \$1.5M (total), \$279K (OU)
- 163. M. Markham, "CAREER: The energetic costs of active sensory and communication signals: Integrating research and education through organismal, cellular, and molecular approaches," NSF, \$719K
- 164. D. Allen, T. Neeson, Y. Hong, "Collaborative Research: MSB-FRA: Scaling Climate, Connectivity, and Communities in Streams," NSF, \$1.4M
- 165. S. Hussaini, (U Tulsa), F. Acquah, (OUHSC), B. Mooers (OUHSC), "HR18-049 Discovery of Indolizidine (-)-237D Analogs as Selective $\alpha 6^*$ Receptor Antagonists," OCAST, \$135K (total), \$13K (OU)
- 166. J. Salazar, N. Aboserwal, R. Palmer, "Shared Aperture Array Antenna for Multiband Radar Applications," Nanowave Technologies Inc, \$130K
- 167. M. Yeary, R. Palmer, P. Chilson, "Development and Commercialization of a Ground-Based Radar to Enable the Next-Generation of Atmospheric Measurements via Unmanned Aircraft Systems (UAS)," OCAST, \$300K
- 168. T. Yu, B. Cheong, R. Palmer, "Technical Support for the Procurement of an S-band Polarimetric Weather Radar," National Central University, Taiwan, \$88K
- 169. R. Palmer, B. Cheong, C. Fulton, J. Salazar, H. Sigmarsson, M. Yeary, T. Yu, Y. Zhang, "Spectrum Efficient National Surveillance Radar (SENSR) - ARRC Risk Reduction Activates," NOAA, \$2.22M
- 170. R. Palmer, C. Fulton, J. Salazar, H. Sigmarsson, "Spectrum Efficient National Surveillance Radar (SENSR) - Development of the All-Digital Horus Demonstrator," NOAA, \$2.9M
- 171. N. Goodman, J. Ruyle, H. Sigmarsson, C. Fulton, M. Yeary, R. Palmer, J. Salazar, "Technologies for Next-Generation Conformal and Reconfigurable Radar Systems," ONR, \$3.5M
- 172. T. Yu, R. Palmer, B. Cheong, "Developing strategies for deploying a network of reflected-array radars," Weathernews Inc., \$97K
- 173. B. Cheong, R. Palmer, T. Yu, "Technical Support for the Design and Test of an X-Band SSPA-Based Polarimetric Weather Radar," Novimet, \$36K

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External Research Grants (cont'd)

- 174. R. Palmer, C. Fulton, J. Salazar, H. Sigmarsson, M. Yeary, "Development of the All-Digital Horus Radar for SENSR," NOAA, \$3.3M
- 175. T. Yu and B. Cheong, "Phase II: SBIR A16-028: Miniature, Software-defined Man-Portable Doppler Radar (MPDR) for Atmospheric Measurement," Helios Remote Sensing Systems Inc., \$164K
- 176. Radar (MPDR) for Atmospheric Measurement," Helios Remote Sensing Systems Inc., \$164K
- 177. M. Xue, K. Brewster, C. Zhang, F. Kong, Y. Jung, "Continued Enhancements to FV3 Model with Advanced Physics through CCPP and Convective-Scale Data Assimilation into GSI and JEDI for Convection-Allowing Forecasting and Evaluations through Hazardous Weather Testbed towards Accelerated Operational," NOAA, \$200K
- 178. N. Kaib, "The Formation and Evolution of Multiple Protostar Systems," NSF, \$288K
- 179. X. Wang, "Scale-dependent Covariance Localization for FV3GDAS 4DVar Data Assimilation System to Improve Global, Hurricane and Cloud Predictions," NOAA, \$194K
- 180. FV3GDAS 4DVar Data Assimilation System to Improve Global, Hurricane and Cloud Predictions," NOAA, \$194K
- 181. Improve Global, Hurricane and Cloud Predictions," NOAA, \$194K
- 182. L. Krumholz, K. D. Hambright, "Dimensions: Collaborative Research: Leveraging Biogeography and Seasonality to Explore Underlying Mechanisms in the Biodiversity of the Cyanobacterial Bloom Microbial Interactome," NSF, \$2M (total), \$810K (OU)
- 183. D. Blume, "Spin and Spatial Correlations of Few-body Systems," NSF, \$294K
- 184. X. Wang, Y. Wang, "Development and Research of GSI based Dual Resolution EnVar Data Assimilation for Convective-Scale," NOAA, \$106K
- 185. Y. Shao, "Rational Design of Pro-apoptotic Bax/Bak Inhibitors," OK-CAST, \$45K
- 186. Y. Shao, "Accelerated Free Energy Calculations on the Catalytic Activity of Mercuric Reductase," ORAU, \$5K
- 187. D. K. Walters, "Collaborative Research: Development of Low Order Modeling Methods for Oscillating Foil Energy Harvesting based on Experimental and Computational Fluid Dynamics," NSF, \$160K
- 188. M. Xue, G. Zhang, X. Xue, "Development and Evaluation of an Ensemble Kalman Filter (EnKF)-Based," Beijing Meteorological Service, \$50K
- 189. (EnKF)-Based," Beijing Meteorological Service, \$50K
- 190. S. Cavallo, "Tropopause polar vortices and multi-scale Arctic predictability," ONR, \$60K
- 191. A. Johnson, X. Wang, "Understanding and Improving the Predictability of Arctic Meso- and Synoptic-scale Cyclones through Multi-scale Ensemble based Data Assimilation and Ensemble Forecast," ONR, \$162K
- 192. J. Tobin, "NRAO Student Observing Support Award to Nickalas Reynolds: Are Close Binaries Formed Through Disk Fragmentation?" NRAO, \$29K

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External Research Grants (cont'd)

193. H. Moreno, "Human-scale surface energy budget and ground thermal responses to soil moisture and vegetation change in flat and complex terrain," ARO, \$92K
194. G. Kosmopoulou, "(EAGER) Collaborative Research DCL: HBCU Network effects, competition and survival of small and minority owned firms in public procurement," NSF, \$76K
195. E. Martin, C. Homeyer, M. Richman, R. McPherson, J. Furtado, "PREEVENTS Track 2: Collaborative Research: Developing a Framework for Seamless Prediction of Sub-Seasonal to Seasonal Extreme Precipitation Events in the United States," NSF, \$1.8M
196. B. Moore, J. Basara, K. Brewster, K. Kloesel, B. Illston, F. Carr, K. Brewster, P. Klein, "National Mesonet Program," Earth Networks Inc/Stinger Ghaffarian Technologies, \$744K
197. P. Skubic, P. Gutierrez, M. Strauss, B. Abbott, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center," DOE, \$148
198. D. Papavassiliou, "Investigation of the effects of turbulent flow on energy and mass transfer close to solid surfaces," NSF, \$326K
199. D. Papavassiliou, "Stability of Surfactant Systems for Oil Mobilization," ACS PRF, \$110K
200. K. Brewster, F. Carr, "Prototyping and Evaluating Key Network-of-Networks Technologies: Project Extension," NOAA, \$194K
201. K. Dresback, R. Kolar, "Steps Towards Automating River Connections and Addressing Precipitation in ADCIRC," NOAA, \$101K
202. K. Calhoun, D. Kingfield, K. de Beurs, "Storms, Forms, and Complexity of Urban Canopy," NASA, \$21K
203. K. Calhoun, D. MacGorman, "Storm Tracking and Lightning Cell Clustering Using Geostationary Lightning Mapping Data for Data Assimilation and Forecast Applications," NOAA, \$110K
204. N. Kaib, "EW Step 2: Understanding the Evolution of the Primordial Kuiper Belt During the Solar System's Early Years," NASA, \$315K
205. B. Wawrik, "Primer Validation and Design Project," Total S.A., \$112K
206. B. L. Cheong, "The Weather Butler Project," Weathernews Americas Inc, \$145K
207. D. Bodine, R. Palmer, S. Torres, B. L. Cheong, C. Fulton, "Understanding the Relationship Between Tornadoes and Debris Through Observed and Simulated Radar Data," NSF, \$787K

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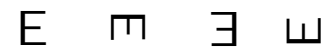


External Research Grants (cont'd)

208. J. White (OSU), S. Crossley, B. Wang, "Understanding an Active and Beneficial Role for Water in Solid-Acid Catalyzed Hydrocarbon Chemistry," \$598K (OU)
209. M. Elwood Madden, "Raman Spectral Database of Aqueous Solutions for Planetary Science," NASA, \$381K
210. M. Nanny, I. Sellers, J. Vogel, J. Kelly, R. Ramesh, "MRI: Acquisition of an Inductively Coupled Plasma Mass Spectrometer (ICP-MS) System to Enable Elemental Analysis in Research, Training and Education," NSF, \$397K
211. A. McGovern, C. Homeyer, C. Potvin, T. Smith, "EAGER: Improving our Understanding of Supercell Storms through Data Science," NSF, \$169K
212. F. Wang, U. Hansmann, "Efficient and Accurate Force Fields for Computer-Aided Drug Design," NIH, \$448K
213. U. Hansmann, "Structural Transitions in Proteins and Protein Assemblies," NIH, \$1.18M
214. E. Bridge, J. Kelly, X. Xiao, "Enhancing and disseminating miniaturized tracking technology for widespread use on small migratory songbirds," NSF, \$303K
215. M. A. Terr (U New Orleans), R. Schmehl (Tulane U), A. V. Callaghan (OU), J. M. Suflika (OU), "Effect of Photochemistry on Biotransformation of Crude Oil," BP, \$1.47M
216. M. Xue, A. Fierro, E. Mansell, D. MacGorman, G. Zhao, "Assimilation of High-Frequency GOES-R Geostationary Lightning Mapper (GLM) Flash Extent Density Data in GSI-Based EnKF and Hybrid for Improving Convective Scale Weather Predictions," NASA, \$599K
217. A. Fierro, J. Gao, A. Clark, E. Mansell, C. Ziegler, D. MacGorman, Y. Wang, A. Lai, "Real time assimilation of GOES-16 total lightning into the NSSL 3DVAR code to improve 0-12h forecasts of high impact weather events at cloud resolving scales," NOAA, \$250K
218. N. Yussouf, M. Erickson (NWS), P. Skinner, A. Fierro, K. Wilson, "Development and NWS Forecaster Evaluation of a Convective-scale Ensemble System for Probabilistic Heavy Rainfall and Severe Weather Forecasts, NOAA, \$417K
219. A. Moore, "Preliminary study of genetic diversity in *Grindelia ciliata*, a promising biofuel crop native to Oklahoma," OCAST, \$100K
220. D. Resasco, B. Wang, "Hydrophobic enclosures in bio-inspired nanoreactors for enhanced phase selectivity. A combined experimental/theoretical approach," DOE, \$650K

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External Research Grants (cont'd)

221. M. Xue, G. Zhang, "Assimilation of High Frequency GOES-R Geostationary Lightning Mapper (GLM) Flash Ex-tent Density Data in GSI-Based EnKF and Hybrid for Improving Convection Scale Weather Predictions," NOAA, \$581K
222. Y. Jung and M. Xue, "Impact of Assimilating Polarimetric Phased Array Radar Observations on Convective-scale Numerical Weather Prediction Model for Severe Weather Forecasts", NOAA, \$346K

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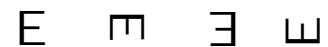
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External Research Grants (cont'd)

223. R. Palmer, B. Cheong, C. Fulton, J. Salazar, H. Sigmarsson, M. Yearly, T. Yu, Y. Zhang, “,” NOAA NSSL, \$2.51M
224. T. Yu, J. Salazar, C. Fulton, H. Bluestein, R. Palmer, B. Cheong, M. Biggerstaff, B. Isom, J. Kurdzo, R. Doviak, X. Wang, M. Yearly, “MRI: Development of C-band Mobile Polarimetric Imaging Radar,” NSF, \$3.1M
225. R. Palmer, B. Cheong, C. Fulton, J. Salazar, H. Sigmarsson, M. Yearly, T. Yu, G. Zhang, Y. Zhang, “ARRC Demonstrator Development Activities for the MPAR Program: CPPAR and Horus,” NOAA NSSL \$2.42M
226. R. Palmer, B. Cheong, “Electromagnetic Sensor Research & Development,” Nanowave Technologies, \$1.5M
227. S. Wolff, J. Bottum, D Atkins, H. Neeman, “EAGER: Fact-Gathering and Planning for a National-Scale Cyberpractitioner Program,” NSF, \$41K
228. G. Monaco et al, “The Role of Regional Organizations in Improving Access to the National Computational Infrastructure,” NSF, \$50K
229. J. Towns et al, “XSEDE: eXtreme Science and Engineering Discovery Environment (supplement),” NSF \$3.7M
230. J. Bottum, M. Livny, H. Neeman, N. Tsinoremas, “RCN: Advancing Research and Education Through National Network of Campus Research Computing Infrastructures – The CaRC Consortium,” NSF, \$748K
231. J. Towns et al, “XSEDE 2.0: Integrating, Enabling and Enhancing National Cyberinfrastructure with Expanding Community Involvement,” NSF, \$131.8M
232. J. Neeman, J. Bottum, D. Atkins, D. Brunson, S. Wolff, “Cyberinfrastructure Leadership Academy,” NSF, \$49K
233. F. Kong, M. Xue, “Technical Support to the Storm-Scale Numerical Weather Prediction Capability for Shenzhen Meteorological Bureau,” Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, \$173K
234. B. Wawrik, Z. Yang, L. Atkinson, “Collaborative Research: Creatine Cycling in Marine Bacterial and Phytoplankton Assemblages,” NSF, \$362K
235. E. Bridge, “Life history, kinship, and the evolution of alternative female reproductive strategies,” \$3K
236. M. Biggerstaff;, “Optimizing radar guidance for triggered lightning,” DARPA, \$200K

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External Research Grants (cont'd)

237. C. Ziegler, M. Biggerstaff, M. Coniglio., "Measurement and analysis of nocturnal mesoscale convective systems and their stable boundary layer environment during PECAN," NSF,. \$583K
238. M. Biggerstaff, "Impact of cloud dynamics on chemical and electrical properties of storms observed during DC3," NSF, \$661K
239. K. Nicholas, "Deoxygenation and Reductive Coupling of Alcohols Catalyzed by Oxo-Metal Complexes," NSF. \$405K
240. S. Schroeder, N. Sloat, "Blue Water Student Internship Program," \$5K
241. S. Schroeder, "Protein and Metal Ion Binding in Viral RNA, HIV Accessory and Regulatory Complexes (HARC)," NIH, \$25K
242. L. Ding, "RII Track-2 FEC: Innovative, Broadly Accessible Tools for Brain Imaging, Decoding, and Modulation," NSF, \$6M
243. L. Ding, "Development of Imaging and EEG Biomarkers to Refine Neuromodulation Treatment Targets in MdDS," LIBR via NdDS, subaward PI, \$55K
244. L. Ding, "Development of the EEG Neuroergonomics Toolbox or EEGNT," FAA, \$243K
245. J. P. Shaffer, "Atom Surface Interactions and Hybrid Quantum Systems for Quantum Engineering Applications," AFOSR, \$750K
246. J. P. Shaffer, "High Sensitivity Absolute Electric Field Sensing with Atoms," National Reconnaissance Office, \$309K
247. J. P. Shaffer, "Control of Rydberg Interactions and Exotic States of Matter," NSF, \$472K
248. M. J. Wenger, "Building a unified theory methodology for identification of elementary cognitive systems," NSF, \$364K
249. B. Wang et al, "High Efficiency Flexible Dilute Nitrides Solar Cells for Space Applications," NASA EPSCoR, \$750K
250. D. LaDue, "REU Site: Real-World Research Experiences at the National Weather Center," NSF, \$885K
251. K. Marfurt, "3D Seismic Attribute Analysis using AASPI Prestack Technology," Korea Institute of Geoscience Mineral Resources, \$35K
252. B. Moore, "National Mesonet Program 2015-2020," Global Science Technology Inc, \$473K
253. S. Cavallo, "Multi-scale Predictability with a New Coupled Non-hydrostatic global model over the Arctic," DOD-ONR, \$273K

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External Research Grants (cont'd)

- 254. X. Chen, "Multi-scale validation of earthquake source parameters to resolve any spatial, temporal or magnitude-dependent variability at Parkfield, CA," NSF, \$224K
- 255. J. Ruyle, "Electrically Small Antenna Design Tool," U.S. Federal Govt, \$110K
- 256. J. Ruyle, "Two-Dimensionality for Conformal Multi-Platform Use," DARPA, \$499K
- 257. X. Wang, "Ensemble Kalman Filter and Hybrid Data Assimilation for Convective-Scale," \$73K
- 258. X. Wang, "Developing and Evaluating GSI-based EnKF-Variational Hybrid Data Assimilation for NCEP NAMRR to Improve Convection-Allowing Hazardous Weather Forecast," NOAA, \$123K
- 259. X. Wang, "Hybrid Data Assimilation for Convective-Scale," NOAA, \$99K
- 260. X. Wang, "Improving Global and Hurricane Prediction b Using Minimum-Cost Large Ensemble in GFS 4DVar Hybrid Data Assimilation System," NOAA, \$389K
- 261. X. Wang, "Tzero Revolution," Weathernews Americas, Inc., \$59K
- 262. X. Wang, "Improving the Understanding and Prediction of Nocturnal Convection through Advance Data Assimilation and Ensemble Simulation in PECAN," NSF, \$602K
- 263. J. Dyer, "Heart Rate Variability Assessment as an Indicator of Health," OUHSC, \$121K
- 264. M. Zaman, "Southern Plains Transportation Center (SPTC)," USDOT, \$7.7M
- 265. M. Zaman, "Matching Support for The Southern Plains Transportation Center," State of Oklahoma, Dept of Transportation, \$3M
- 266. K. De Beurs, "Storms, Forms, and Complexity of the Urban Canopy: How Land Use, Settlement Patterns, and the Shapes of Cities Influence Severe Weather," NASA, \$437K
- 267. E. Baron, "Models of Interacting Supernovae: Probing the Circumstellar Environment," NASA, \$381K
- 268. A. Fierro, K. Calhoun, E. Mansell, C. Ziegler, D. MacGorman, J. Gao, "Assimilation of GOES-R total lightning into GSI to improve short-term forecasts of high impact weather events at cloud resolving scales," NOAA, \$230K
- 269. M. Xue, K. Brewster, Y. Jung, , "Advanced Data Assimilation and Prediction Research for Convective-Scale 'Warn-on-Forecast'," NOAA, \$450K
- 270. M. Xue, F. Kong, Y. Jung, N. Snook, "mproving Initial Conditions and their Perturbations through Ensemble-Based Data Assimilation for Optimized Storm-Scale Ensemble Prediction in Support of HWT Severe Weather Forecasting," NOAA, \$249K

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External Research Grants (cont'd)

271. M. Xue, K. Brewster, F. Kong, "Storm-Scale Ensemble Prediction Optimized for Heavy Precipitation Forecasting in Support of the Hydrometeorological Testbed (HMT)," NOAA, \$236K
272. J. Kelly, E. Bridge, P. Chilson, A. McGovern, K. deBeurs, J. Reedy, L. Jervis, "NRT: Aeroecology as a testbed of interdisciplinary STEM training," \$2.95M
273. F. Carr, J. Brotzge, "National Mesonet Program", GST and Earth Networks, \$50K
274. F. Carr, K. Brewster, "National Mesonet Program," \$100K
275. F. Carr, J. Brotzge, K. Brewster, "Network of Networks: Preliminary Study," NOAA/NWS Office of Science and Technology, \$210K

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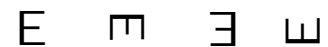


External Research Grants (cont'd)

- 276. J. van de Lindt, B. Ellingwood, A. Cerato, N. Wang, C. Nicholson et al, "NIST Center for Risk-Based Community Resilience Planning," \$1.37M
- 277. J. van de Lindt, A. Cerato, N. Wang, "A Risk-Informed Decision Framework to Achieve Resilient and Sustainable Buildings that Meet Community Objectives," NSF, \$380K
- 278. J. Straka, K. Kanak, "Challenges in understanding tornadogenesis and associated phenomena," NSF, \$750K
- 279. J. Straka, "Challenges in understanding tornadogenesis and associated phenomena (supplement)," NSF, \$29K
- 280. P. Kirstetter, B. L. Cheong, T.-Y. Yu, "Deployment of a Novel Solid-state Polarimetric Weather Radar for Hydrology," NSF, \$87K
- 281. B. L. Cheong, R. D. Palmer, "Development of a Novel Solid-State Polarimetric Weather Radar PX-10,000," Nanowave Technologies, Inc., \$550,000,
- 282. K. Nicholas, "Catalytic Deoxydehydration," DOE, \$438K
- 283. M. Libault, "CAREER: Exploring the Transcriptional Regulatory Networks Controlling the Early Stages of Legume Nodulation," NSF, \$1.1M
- 284. B. Shiau, D. Papavassiliou, J. Harwell, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium, \$419K
- 285. S. Crowell, B. Moore, Y. Luo, "Improved Parameterization of Carbon Cycle Models Across Scales Using OCO-2 Measurements of XCO2 and SIF," NASA, \$477K
- 286. B. Wawrik, "MGMIC: Metagenome Analysis for Corrosion Tracking," OU Biocorrosion Center, \$131K
- 287. B. Wawrik, A. Callaghan, "Development of Techniques for the Quantification of Functional Gene Expression Associated with Biocorrosion," OU Biocorrosion Center, \$37K
- 288. B. Wawrik, D. Bronk, "Collaborative Research: Determining Rates of Group-specific Phytoplankton and Bacterial Uptake of Inorganic and Organic Nitrogen by means of Stable Isotope Techniques," NSF, \$770K
- 289. A. Callaghan, B. Wawrik, J. Suflita, "Biochemistry and Genetics of Anaerobic Alkane Metabolism: Interrogation of Sulfate-Reducing Isolates and Enrichments Using Genome-Enabled and Proteomic Approaches," NSF, \$725K
- 290. B. Wawrik, "Determining Rates of Group-specific Phytoplankton and Bacterial Uptake of Inorganic and Organic Nitrogen by Means of Stable Isotope Techniques," NSF, \$10K

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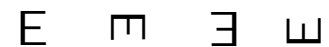


External Research Grants (cont'd)

291. B. Wawrik, G. Sinclair, "Transcriptomic Response to Nutrient Depletion of Marine Dinoflagellates," Gordon and Betty Moore Foundation, \$70K in-kind
292. Joseph M. Suflita. Co-PIs: A. Callaghan, L. Gieg, Z. He, B. Wawrik, J. Zhou, "Extending Knowledge of Anaerobic Hydrocarbon Metabolism: Linking Metabolism, Functional Gene Molecular Markers and the GeoChip," ConocoPhillips, \$999K
293. A. Striolo, "Anti-Agglomerants Performance in Hydrates Management: Fundamental Insights," EPSRC, £330K
294. A. Striolo et al, "ShaleXenvironment," European Commission, €3M
295. A. Striolo, "Flow Transport in Shale Rocks," Halliburton, £69K
296. A. Striolo, D. Cole, "Nanopore Confinement of C-H-(O) Mixed-Volatile Fluids Relevant to Subsurface Energy Systems," DOE, £60K
297. A. Striolo, "Hydrates Inhibitor Research," Halliburton, £69K
298. A. Striolo, "Fracking Fundamentals," Marie Curie Career Integration Grant, €100K
299. J. Li, "Targeting Mosquito FREP1 Protein for Malaria Control," NIH, \$424K
300. J. Li, "CAREER: Genetic and Molecular Mechanisms of Parasite Infection in Insects," NSF, \$783K
301. D. Atkins, J. Li, "Memory T cell-mediated protecting against malaria," NIH, \$76K
302. J. Li, "Genomics analysis of Anopheles gambiae mosquitoes to Plasmodium falciparum parasite Infection," OCAST, \$135K
303. P. Klein, P. B. Chilson, E. Fedorovich, A. Shapiro, D. Turner, "Low-level jets in the nocturnal stable boundary layer: structure, evolution, and interactions with mesoscale atmospheric disturbances," NSF, \$984K
304. E. Bridge, "The Electronic Transponder Analysis Gateway (ETAG): An Animal Behavior Observatory," NSF, \$315K
305. B. Capogrosso-Sansone, "Multi-Worm Algorithm for Path Integral Quantum Monte Carlo in Ultracold Dipolar Gases, NSF, \$293K
306. K. Dresback, R. Kolar, "Performance Optimization of the Advanced Circulation (ADCIRC) Model," Intel Parallel Computing Center, \$300K
307. U. Hansmann, "Modeling the molecular mechanism of amyloid oligomer and fibril self assembly," OCAST, \$90K

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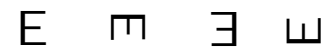


External Research Grants (cont'd)

308. J. Wicksted, A. Knoedler et al, "Adapting Socio-ecological Systems to Increased Climate Variability," NSF, \$20M + \$4M Regents (total), \$7.0M + \$1.9M Regents (OU)
309. M. Engle et al, "Resilience and vulnerability of beef cattle production in the Southern Great Plains under changing climate, land use and markets," \$9.5M (total), \$1.9M (OU)
310. R. Palmer, G. Zhang, Y. Zhang, T. Yu, M. Yeary, S. Karimkashi, C. Fulton, B. Cheong, "Multi-Mission Phased Array Radar Risk Reduction: A Collaborative Effort with the ARRC at the University of Oklahoma," NOAA, \$1.5M
311. R. Palmer, G. Zhang, Y. Zhang, T. Yu, M. Yeary, Y. Hong, J. Crain, P. Chilson, "Next Generation Weather Radar Technology," NOAA, \$900K
312. R. Palmer, D. Bodine, S. Torres, B. Cheong, C. Fulton, "Understanding Polarimetric Radar Tornadic Debris Signatures Using Modeling, Simulations, and Field Measurements,," NSF, \$860K
313. A. Callaghan, "Elucidation of Alkene Metabolism in Two Sulfate-reducing Isolates via Metabolite Profiling and Transcriptomics," NSF, \$848K
314. D. LaDue, K. Kloesel, "REU Site: Research Experiences for Undergraduates at the National Weather Center," NSF, \$822K
315. J. Brotzge, M. Xue, N. Snook, Y. Jung, A. McGovern, "The Severe Hail Analysis, Representation, and Prediction (SHARP) Project," NSF, \$819K
316. L. Krumholz, J. Zhou, M. McInerney, J. Wall, "Characteristics of H2 Producing Biological Systems Operating at 1 nM H2 Concentration," DOE, \$819K (total), \$693K (OU)
317. P. Chilson, E. Fedorovich, R. Palmer, "Studies of the Atmospheric Boundary Layer Using Numerical Simulations Coupled With Radar/Sodar-Based Field Experiments," NSF, \$757K
318. M. Xue, K. Brewster, F. Kong, "Establishment of Precision Weather Analysis and Forecasting Systems (PWAFS) for the Jiangsu Province Meteorological Bureau (JSMB)," NRIET, \$505K
319. H. Neeman, D. Brunson, J. Deaton, S. Radhakrishnan et al, "CC-NIE: OneOklahoma Friction Free Network," NSF, \$500K
320. F. Kong, M. Xue, "Further Development of the Storm-Scale Numerical Weather Prediction Capability for Shenzhen Meteorological Bureau," Shenzhen, \$479K
321. E. Bridge, J. Kelly, "Optimizing Grassland Bird Conservation in an Era of Biofuel Production," USDA, \$466K

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External Research Grants (cont'd)

322. R. Kolar, "Dynamic Integration of Natural, Human, and Instructure Systems for Hurricane Evacuation and Sheltering," NSF, \$456K
323. L. Ding, "Neuroimaging Study of Mental Fatigue," FAA, \$430K
324. U. Hansmann, "Development of Generalized-Ensemble Algorithms and their Application in Protein Studies," NSF, \$410K
325. L. Ding, "Large-Scale Computational Neuroimaging of Brain Electrical Activity," NSF CAREER, \$400K
326. P. Attar, "Optimal Spatiotemporal Reduced Order Modeling for Nonlinear Structural Dynamics," NSF, \$360K
327. B. L. Cheong, Y. Jung, G. Zhang, "Support for X-band Solid-state Weather Radar Development," WeatherLink, \$334K
328. P. Vedula, P. J. Attar, "Fast simulations of turbulent flows based on spatiotemporal statistical information," NSF, \$330K
329. M. Xue, K. Brewster, F. Kong, "Development of a Short-Range Realtime Analysis and Forecasting System based on the ARPS for Taiwan Region Year 3 (IA#24) and Year 4 (IA #25)," NOAA, \$310K
330. E. Bridge, J. Kelly, X. Xiao, "Enhancing and disseminating miniaturized tracking technology for widespread use on small migratory songbirds," NSF, \$302K
331. J. Kelly, L. Gruenwald, P. Chilson, V. Lakshmanan, E. Bridge, "Advancing Biological Interpretations of Radar Data," NSF EAGER, \$299K
332. L. Ding, "High-Resolution Noninvasive Computational Neuroimaging," OCAST, \$283K
333. F. Kong, "Further Development to the Storm-Scale Numerical Weather Prediction Capability for Shenzhen Meteorological Bureau," SIATCAS, \$251K
334. R. Slatt, Consortium from 14 oil and gas company, \$245K
335. J. Brotzge, F. Carr, "Prototyping and Evaluating Key Network-of-Networks Technologies: Project Extension," NOAA, \$210K
336. Y. Jung, M. Xue, G. Zhang, "Development of a Polarimetric Radar Data Simulator for KLAPS," KMA, \$176K
337. J. Ruyle, "BRIGE: Investigation of Slot Antenna Recon figuration Mechanisms," NSF, \$175K
338. J. Brotzge, F. Carr, "CASA Warning System Innovation Institute," U Mass, \$160K

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OneOklahoma Cyberinfrastructure Initiative

External Research Grants (cont'd)

339. J. Kelly, "Developing Innovative Tools to Use Weather Radar Data to Assess and Monitor Impacts of Existing and Future Energy Facilities on Aerial Faunas in California," CIEE, \$150K (total), \$49K (OU)
340. J. Brotzge, F. Carr, "Prototyping and Evaluating Key Network-of-Networks Technologies," NOAA, \$145K
341. T. Yu, Y. Wang, R. Palmer, B. Cheong, "Algorithm development for solid-state polarimetric weather radars," Toshiba, \$130K
342. M. Xue, K. Brewster, F. Kong, "Establishment of an Urban-Scale Weather Forecasting System (USWFS) for the Su Zhou Meteorological Bureau (SZMB)," \$127K
343. L. Ding, "Neurophysiological Assessment of Mental Fatigue and Cognitive Performance," FAA, \$115K
344. K. Dresback, R. Kolar, "Next Generation ADCIRC Tidal Database: Phase 2 - West Coast," DOD, \$75K
345. K. Dresback, R. Kolar, "Next Generation ADCIRC Tidal Database," NOAA, \$75K
346. P. Risser, J. Duckles, J. Bratton, NSF I-Corps, \$50K
347. R. Palmer, M. Yeary, "System and Software Engineering Support Services for CGI," CGI, \$46K
348. M. Yeary, M. Xue, "GRDS: Request to support a Native American Indian graduate student beginning his PhD within the CASA Engineering Research Center," NSF, \$32K

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External Research Grants (cont'd)

- 349. I. Y. Akkutlu, J. Callard, C. Rai, C. Sondergeld, "OU Shale Gas and Unconventional Reservoir Research Cooperative," \$2.8M per year
- 350. J. P. Shaffer, T. Pfau, "A Rydberg Atom Electric Field Sensor," DARPA-ARO, \$1.18M (total), \$1.06M (OU)
- 351. Y. Luo, "Data Synthesis and Data Assimilation at Global Change Experiments and Fluxnet toward Improving Land Process Models," DOE, \$1.05M
- 352. F. Kong, M. Xue, K. Brewster, "Establishment of an Improved Numerical Weather Forecasting System for Chongqing Meteorological Service," Chongqing Institute of Green and Intelligent Technology, China, \$852K
- 353. G. Zhang, M. Xue, B. L. Cheong, T. J. Schurr, "Advanced Study of Precipitation Microphysics with Multi-Frequency Polarimetric Radar Observations and Data Assimilation," NSF, \$637K
- 354. J. P. Shaffer, "A Quantum Hybrid System for Linking Rydberg Atom Quantum Gates. NSF, \$465K
- 355. J. P. Shaffer, "Rydberg Atom Interactions and Collective Behavior," NSF, \$436K
- 356. J. P. Shaffer, "Interactions in Cold Rydberg Gases," NSF, \$422K
- 357. J. Cruz, "CIF: Small: Two-Dimensional Channel Modeling, Detection and Coding for Shingled Magnetic Recording," NSF, \$418K
- 358. M. Yuan, "Supplement to Developing and Evaluating the Effectiveness of the Location-based Offender Monitoring System for Offender Supervision," National Institute of Justice, \$396K
- 359. X. Wang, M. Xue, F. Kong, "Optimal Design of Multi-scale Ensemble Systems for Convective-Scale Probabilistic Forecasting," NSF, \$359K
- 360. F. Kong, M. Xue, "Further Development of the Storm-Scale Numerical Weather Prediction Capability for Shenzhen Meteorological Bureau," Shenzhen Institute of Advanced Technology, China, \$251K
- 361. J. Snow & F. Fondjo Fotou (Langston U), "MRI: Acquisition of a High Performance Computing Cluster for Research and Education," NSF, \$250K
- 362. M. Xue, K. Brewster, Y. Jung, "Advanced Data Assimilation and Prediction Research for Convective-Scale Warn-on-Forecast," NOAA, \$243K
- 363. I.Y. Akkutlu, "Multi-scale Characterization of Transport Phenomena in Shales for Improved Gas Recovery," Devon Energy, \$200K
- 364. M. Xue, R. McPherson, J. Brotzge, B. Moore, "Very High-Resolution Dynamic Downscaling of Regional Climate and Hydrology," USG, \$24K
- 365. J. Brotzge, F. Carr, "CASA DFW Testbed Enhancement: Task B of National Mesonet Program (NWP)," Earth Networks Inc., \$25K

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External Research Grants (cont'd)

366. R. Voronov, "Intra-Thrombus Chemo-Transport and Local Stress Mechanics under Flow," American Heart Association Postdoctoral Fellowship, \$150K
367. X. Wang, M. Xue, "Improving High Resolution Tropical Cyclone Prediction using GSI-based Hybrid Ensemble-Variational Data Assimilation System for HWRF," NOAA, \$150K
368. I. Y. Akkutlu, "Molecular Theory of Capillarity in Kerogen - A Multi-component Approach to Predict Shale Gas/Liquid In-place and Transport in Nanopores," Devon Energy, \$150K
369. S. Dhall, L. Gruenwald, "Autonomous Database Partitioning using Data Mining for High End Computing," NSF, \$150K
370. M. Xue, K. Brewster, F. Kong, "Ensemble Simulation of GOES-R Proxy Radiance Data from CONUS Storm-Scale Ensemble Forecasts, Product Demonstration and Assessment at the Hazardous Weather Testbed GOES-R Proving Ground," NOAA, \$126K
371. M. Xue, K. Brewster, F. Kong, "Ensemble Simulation of GOES-R Proxy Radiance Data from CONUS Storm-Scale Ensemble Forecasts, Product Demonstration and Assessment at the Hazardous Weather Testbed GOES-R Proving Ground," NOAA, \$94K
372. K. Brewster, M. Xue, "High Resolution Data Assimilation for Trajectory Improvement," DOD-Air Force, \$79K
373. F. Kong, "CAPS support to the WRF Lightning Forecast Algorithm for the NOAA R3 effort," NOAA GOES-R/Universities Space Research Assn, \$48K
374. R. McPherson, M. Shafer, Y. Hong, "Utilization of Regional Climate Science Programs in Reservoir and Watershed Impact Assessments," OSU Water Resources Responses to Climate Change: Pilot Study, \$43K
375. P. Attar, "Numerical Simulation of a Membrane Micro Air Vehicle in a Gust Field, Ohio Aerospace Institute, \$35K
376. J.R. Cruz, "Signal Processing for Magnetic Recording Channels," Hitachi Global Storage Technologies, Inc., Director, \$30K
377. J.R. Cruz, "Equalization, Detection, and Coding Algorithms for Bit Patterned Media Recording," Advanced Storage Technology Consortium, \$17K
378. L. Sells, J. Goulden, H. Aboudja, "LittleFe grant," LittleFe project, \$2.5K
379. L. Sells, J. Goulden, "Early Adopter Grant," NSF/TCPP, \$2.5K

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External Research Grants (cont'd)

380. B. Moore III et al, "Department of the Interior South-Central Regional Climate Science Center," US Dept of the Interior, \$3.5M (total), \$1.4M (OU)
381. A. Striolo, D. Resasco et al, "Center for Application of Single-Walled Carbon Nanotubes," DOE, \$1M
382. J. K. Shen, "CAREER: Electrostatic Mechanisms in Protein Stability and Folding, NSF, \$773K
383. Y. Kogan, "Parameterization of cumulus convective cloud systems in mesoscale forecast models," ONR, \$594K
384. X. Wang, M. Xue, F. Kong, "Optimal Design of Multi-scale Ensemble Systems for Convective-Scale Probabilistic Forecasting," NSF, \$395K
385. R. D. Palmer, T.-Y. Yu, "NMQ and WDSS-II for the KMA radar network: Real-time, effective, and integrated weather products," Space Environment Laboratory, Inc., \$361K
386. B. Grady, A. Striolo, "Novel Supramolecular Structures of Laterally Confined Amphiphilic Molecules," NSF, \$335K
387. D. Resasco, D. Papavassiliou et al, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium, \$331K
388. C. Y. Tang , R. Ramakumar, N. Jiang , "Control and Operation of Large-Scale Wind Farms in the Power System", NSF, \$231K
389. J. Shen, "Electrostatic Modulation of Protein Stability and Folding," NIH, \$1.4M
390. Y. Wang, "Theoretical Tools for Measuring Dark Energy from Galaxy Clustering," DOE, \$230K
391. F. Kong, M. Xue, "Further Enhancement to the Hourly Assimilation and Prediction System (HAPS) for Shenzhen Meteorological Bureau." Shenzhen Institute of Advanced Technology, Chinese Academy of Science, \$228K
392. P. Attar, P. Vedula, "Multi-fidelity Modeling and Simulation (M&S) Tool for Nonlinear Aeroelasticity," Advanced Dynamics, \$160K
393. B. Eskridge, "CDI-TYPE I: RUI: Emergent Hierarchies of Leaders in Multi-Robot Systems," NSF, \$159K
394. A. Striolo, "Mixed-Volatile Fluids Relevant to Subsurface Energy Systems," DOE, \$120K
395. P. Skubic, M. Strauss, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center (Supplement)," NSF, \$110K
396. P. Attar, "High-Fidelity Computational Aeroelastic Solver Research," Ohio Aerospace Institute, \$53K
397. P. Skubic, M. Strauss, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center (Supplement)," NSF, \$50K

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External Research Grants (cont'd)

398. P. Skubic, M. Strauss, "University of Oklahoma Contribution to OSG Software Development," Brookhaven National Laboratory, \$50K.
399. P. Attar, "Computational Model Development and Experimental Validation Measurements for Membrane-Batten Wing," Ohio Aerospace Institute, \$43K
400. A. Striolo, "Reduced Carbon in Earth's Crust and Mantle I," Alfred P. Sloan Foundation, \$39K.
401. J. Gao, "Advancing Research on Realtime Weather-Adaptive 3DVAR Analyses with Automatic Storm Positioning and On-demand Capability," NOAA, \$36K
402. M. Xue, "Probabilistic Forecasting for Aviation Decision Aid Applications," Impact Technologies, \$20K
403. P. Attar, P. Vedula, "Towards Better Modeling and Simulation of Nonlinear Aeroelasticity On and Beyond Transonic Regimes," Advanced Dynamics, \$20K
404. P. Attar, P. Vedula, "High-Fidelity Computational Aeroelastic Models in Support of Certification Airworthiness of Control Surfaces with Freeplay and Other Nonlinear Features," Advanced Dynamics, \$9K

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External Research Grants (cont'd)

405. H. Neeman, D. Brunson (OSU), J. Deaton (OneNet), J. He (Noble Foundation), D. Schoenefeld (TU), J. Snow (Langston U), M. Strauss (OU), X. Xiao (OU), M. Xue (OU), "Oklahoma Optical Initiative," NSF, \$1.17M
406. H. Neeman, M. Jensen, M. Strauss, X. Xiao, M. Xue, E. Baron, K. Dresback, R. Kolar, A. McGovern, R. Palmer, D. Papavassiliou, H. Severini, P. Skubic, T. Trafalis, M. Wenger, R. Wheeler (Duquesne U), "MRI: Acquisition of Extensible Petascale Storage for Data Intensive Research," NSF, \$793K
407. D. Resasco, J. Harwell, F. Jentoft, K. Gasem, S. Wang, "Center for Interfacial Reaction Engineering (CIRE)," DOE EPSCoR, \$2.4M (\$1.97M OU)
408. P. Skubic, M. Strauss, B. Abbott, P. Gutierrez, "Experimental Physics Investigations Using Colliding Beam Detectors at Fermilab and the Large Hadron Collider (LHC) (TASK A) 2010-2013 Renewal," DOE, \$2.8M
409. R. Palmer, Y. Zhang, G. Zhang, T. Yu, M. Yearly, Y. Hong, J. Crain, P. Chilson, "Next Generation Phased Array," NSSL, \$2M
410. P. Skubic, M. Strauss, B. Abbott, P. Gutierrez, "Experimental Physics Investigations Using Colliding Beam Detectors at Fermilab and the Large Hadron Collider (LHC) (TASK A) 2010-2013 Renewal-Revision," DOE, \$1.52M
411. D. Cole, Alberto Striolo, "Structure and Dynamics of Earth Materials, Interfaces and Reactions," DOE, \$1.5M (\$90K OU)
412. R. Sigal, F. Civan, D. Devegowda, "Simulation of Shale Gas Reservoirs Incorporating the Correct Physics of Capillarity and Fluid Transport," Research Partnership to Secure Energy for America (RPSEA), \$1.05M
413. M. Biggerstaff, J. Straka, L. Wicker, Zrnica, Zahari, "MRI Development of C-Band Mobile Polarimetric Weather Radars," NSF, \$989K (\$439K OU)
414. D. Resasco, D. Papavassiliou et al, "Carbon Nanotube Technology Center," DOE, \$925K
415. M. Saha, D. Papavassiliou, A. Striolo, K. Mullen, B. Grady, C. Altan, D. Resasco, "Experimental and theoretical studies of carbon nanotube hierarchical structures in multifunctional polymer composites," DoD-EPSCoR, \$897K
416. E. Mansell, J. Straka, C. Ziegler, D. MacGorman, "Numerical modeling studies of storm electrification and lightning," NSF, \$817K
417. E. Rasmussen, J. Straka, K. Kanak, "Collaborative Research: Challenges in understanding tornadogenesis and associated phenomena, \$755K (\$489K OU)
418. J. Straka, K. Kanak, "Challenges in tornadogenesis and associated phenomena," NSF, \$584K

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419. M. Xue, F. Kong, "Advanced Multi-Moment Microphysics for Precipitation and Tropical Cyclone Forecast Improvement with COAMPS," ONR, \$592K
420. J. Straka, K. Kanak, "Collaborative Research: Challenges in Understanding Tornadoogenesis and Associated Phenomena," NSF, \$515K
421. D. MacGorman, E. Mansell, C. Ziegler, A. Fierro, M. Xue, "Techniques for Assimilating Geostationary Lightning Mapper Data and Assessment of the Resulting Impact on Forecasts," NOAA, \$415K
422. M. Xue, F. Kong, K. Brewster, X. Wang, "A Partnership to Develop, Conduct, and Evaluate Realtime High-Resolution Ensemble and Deterministic Forecasts for Convective-scale Hazardous Weather: Moving to the Next Level," NOAA CSTAR, \$375K
423. M. Xue, K. Brewster, J. Gao, X. Wang, "Advanced Data Assimilation and Prediction Research for Convective-Scale 'Warn-on-Forecast,'" \$500K, NOAA
424. X. Wang, "Improving satellite radiance data assimilation using a hybrid ensemble-Gridpoint Statistical Interpolation (GSI) method for global numerical weather prediction," NASA, \$276K
425. X. Wang, M. Xue, "Improving NOAA operational global numerical weather prediction using a hybrid-ensemble Kalman filter data assimilation and ensemble forecast system," NOAA, \$207K
426. D. Resasco, D. Papavassiliou et al, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium (AEC), \$333K
427. D. Oliver, "Data analysis and inversion for mobile nanosensors," AEC, \$320K
428. R. Palmer, T. Yu, G. Zhang, M. Yearly, P. Chilson, Y. Zhang, J. Crain, "Advancements in Phased Array Weather Radar Research at OU," NOAA National Severe Storms Laboratory (NSSL), \$270K
429. A. Striolo, "The Emergent Behavior of Solid Nanoparticles at Oil-Water Interfaces: A Multi-Scale Thermodynamic Approach to Enable Bio-Oil Upgrade," NSF, \$238K
430. M. Xue, K. Brewster, F. Kong, "Development of a Short-Range Realtime Analysis and Forecasting System based on the ARPS for Taiwan Region," NOAA, \$200K
431. J. Straka, K. Kanak, "Formative dynamics of the mammatus clouds in thunderstorm cirrus," NSF, \$318K
432. M. Yearly, C. Tang, "Computationally Efficient Linear Transforms for Remote Sensing Systems," NSF, \$299K
433. A. Striolo, "Probing regular solution theory for mixed amphoteric/ionic surfactant systems by molecular dynamics simulations," ACS, \$100K

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External Research Grants (cont'd)

434. K. Brewster, M. Xue, F. Kong, meteorology project, \$211K
435. M. Xue, meteorology project, \$120K
436. A. McGovern, "Learning to guide search in large state spaces," IBM DARPA, \$95K
437. J. Straka, K. Kanak, "Supplement: Challenges in tornadogenesis and associated phenomena (VORTEX2)," NSF, \$87K
438. F. Kong, M. Xue, "Establishment of an Experimental Real-Time Short-Term Storm Prediction System for Shenzhen Meteorological Bureau," \$58K
439. J. Straka, "Improved Understanding/Prediction of Severe Convective Storms and Attendant Phenomena through Advanced Numerical Simulation," NSF, \$58K
440. M. Xue, "Assimilation of NEXRAD Radial Winds in a Regional Mesoscale Model," Miss State U, \$79K
441. J. Cruz, R. Todd, "Medium-Density Parity-Check Codes for Tape Systems," INSIC, \$36K
442. M. Xue, D. Stensrud, J. Gao, "Advancing Warn on Forecast – Storm-scale Analysis of Vortex 2 Thunderstorms," NSSL, \$70K
443. P. Attar, "High-Fidelity Computational Aeroelastic Solver Research," Ohio Aerospace Institute, \$60K
444. J. Straka, K. Kanak, "Development of Unmanned Aircraft System for Research in a Severe Storm Environment and Deployment within the VORTEX 2," NSF, \$44K
445. J. Cruz, "Equalization, Detection, and Coding Algorithms for Bit Patterned Media Recording Channels," International Storage Industry Consortium (INSIC), \$35K
446. J. Cruz, R. Todd, "Signal Processing for Magnetic Recording Channels," private company, \$30K
447. P. Attar, P. Vedula, "Deterministic and Statistical Characterization of the Impact of Control Surface Freeplay on Flutter and Limit-Cycle Oscillation (LCO) using Efficient Computational Modeling," Advanced Dynamics, \$30K
448. P. Attar, P. Vedula, "Novel Reduced Order in time Models for Problems in Nonlinear Aeroelasticity," Advanced Dynamics, \$29K
449. F. Carr, J. Straka, "Severe storm research," Jonathon Merage Foundation, \$21K
450. F. Carr, J. Straka, "Severe storm research," Jonathon Merage Foundation, \$20K

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External Research Grants (cont'd)

- 451. A. Striolo, "Electrolytes at Solid-Water Interfaces: Theoretical Studies for Practical Applications," DOE EPSCoR, \$450K
- 452. A. Striolo, Saha, "Experimental and Theoretical Studies of Carbon Nanotube Hierarchical Structures in Multifunctional Polymer Composites," DOD EPSCoR, \$450K
- 453. D. Cole (ORNL), A. Striolo, "Structure and Dynamics of Earth Materials, Interfaces and Reactions," DOE, \$1.5M (\$75K OU)
- 454. D. Papavassiliou, A. Striolo, "Effects of Hydrophobicity-Induced Wall Slip on Turbulence Drag and Turbulence Structure," NSF, \$230K
- 455. A. Striolo, D. Resasco, U. Nollert, "Understanding the Interactions between Carbon Nanotubes and Cellular Membranes," NSF, \$380K
- 456. M. Xue, Y. Hong, X. Hu (GSU), "Integrated Weather and Wildfire Simulation and Optimization for Wildfire Management," NSF, \$997K (\$483K OU)
- 457. Y. Hong, "Next Generation QPE: Toward a Multi-Sensor Approach for Integration of Radar, Satellite, and Surface Observations to Produce Very High-resolution Precipitation Data," NOAA/OAR/NSSL via CIMMS, \$83K
- 458. R. Palmer, Y. Hong, "Phased Array Technology for Weather Radar Applications," NOAA/OAR/NSSL via CIMMS, \$426K
- 459. Y. Hong, Baski (OSU), "Proactive approach to transportation resource allocation under severe winter weather emergencies," OK-DOT/OTC, \$261K (\$101K OU)
- 460. R. Palmer, Y. Hong, "Atmospheric Observations using PhasedArray Technology," \$340K
- 461. Y. Hong, "Toward Improved Flood Prediction and Risk Mitigation: Capacity Building for Africa," NASA, \$87K
- 462. Y. Hong, "Improving NASA Global Hazard System and Implementing SERVIR-Africa," NASA, \$272K
- 463. Y. Hong, "Link SERVIR-Africa Work to NASA Land Information System: Workshop Training and Data Assimilation of GRACE to NASA-OU Hydrologic Model," NASA, \$10K
- 464. R. Adler (NASA), Y. Hong, "Global Hazard (Flood-Landslide) Decision-Support System," NASA, \$900K
- 465. S. Schroeder, "CAREER: Advancing Viral RNA Structure Prediction," NSF, \$750K

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External Research Grants (cont'd)

466. P. Attar, "High Fidelity Computational Aeroelastic Analysis of a Flexible Membrane Airfoil Undergoing Dynamic Motion," Ohio Aerospace Institute, \$35K
467. P. Attar, "Computational Model Development and Experimental Validation Measurements for Membrane-Batten Wing" Flexible Membrane Airfoil Undergoing Dynamic Motion," Ohio Aerospace Institute, \$43K
468. K. Droegemeier, F. Kong, P. Attar, "A Partnership to Develop, Conduct, and Evaluate Realtime High-Resolution Ensemble and Deterministic Forecasts for Convective-scale Hazardous Weather," NOAA, \$375K
469. M. Xue, G. Zhang, K. Brewster, F. Kong, "Prediction and Predictability of Tropical Cyclones over Oceanic and Coastal Regions and Advanced Assimilation of Radar and Satellite Data for the Navy Coupled Ocean-Atmosphere Mesoscale Prediction System," ONR/DOD EPSCoR, \$476K; OK Board of Regents \$100K
470. S. Ahalt, A. Apon, D. Lifka, H. Neeman, "NSF Workshop High Performance Computing Center Sustainability," NSF, \$49K (\$0 OU)
471. Y. Luo, S. Lakshmivarahan, "Development of a Data Assimilation Capability towards Ecological Forecasting in a Data-Rich Era," NSF, \$1.08M
472. Y. Luo, D. Schimmel (NEON), J. Clark (Duke U.), Kiona Ogle (U. Wyoming), S. LaDeau (Cary Institute of Ecosystem Study), "RCN: Forecasts Of Resource and Environmental Changes: Data Assimilation Science and Technology (FORECAST)," NSF, \$500K
473. J. Straka, K. Kanak, Davies-Jones, H. Neeman, "Challenges in understanding tornadogenesis and associated phenomena," NSF, \$854K
474. P. Risser et al, "A cyberCommons for Ecological Forecasting," NSF, \$6M (\$2.78M OU)
475. M. Xue, X. Wang, X. Li (OSU), R. Barnes, S. Sanielevici (PSC), H. Neeman, "Enabling Petascale Ensemble-Based Data Assimilation for the Numerical Analysis and Prediction of High-Impact Weather," NSF, \$1.2M (\$902K OU)
476. P. Skubic, B. Abbott, P. Gutierrez, M. Strauss, "ATLAS Southwest Tier 2 Computing Center," NSF, \$600K/year (\$60K/year OU)
477. Y. Hong, "Evaluation of NASA Global Hazard System," NASA, \$45K

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External Research Grants (cont'd)

478. J Wicksted, F. Waxman et al, "Building Oklahoma's Leadership Role in Cellulosic Bioenergy," NSF EPSCoR, \$15M (\$5.7M OU)
479. D.S. Oliver, software, \$16.7M
480. K.K. Muraleetharan, G. Miller, and A. Cerato, "Understanding and Improving the Seismic Behavior of Pile Foundations in Soft Clays," NSF, \$1.15M (\$500K OU)
481. K. Droegemeier, F. Kong, "Multisensor Studies of Precipitation for Model Verification and Data Assimilation," U Minn, (\$7K OU)
482. K. Droegemeier, M. Xue, F. Kong, "Observing System Simulation Experiments for Airborne Weather Sensors," HRL, (\$33K OU)
483. M. Nollert, Scholarship, FD-OMRF, \$12K
484. R. Sigal, R. Philp, C. Rai., S. Shah, R. Slatt, C. Sondergeld, D. Zhang, energy company, \$1.9M
485. B. Grady, D. Schmidtke, A. Striolo, A. Cheville, D. Teeters, "Polymer Nanostructures on Solid Surfaces," \$208K (\$125K OU)
486. T. Conway, "E. coli Model Organism Resource," UN-Purdue, (\$685K OU)
487. R. Kolar, "Storm Surge Modeling in SE Louisiana - 2006," ARCADIS, (\$37K OU)
488. D. Cole (ORNL), A. Striolo, "Rates and Mechanisms of Mineral-Fluid Interactions at the Nanoscale," DOE, \$1.65M (total), (\$55K OU)
489. R. Kolar, "A Prototype Operational Modeling System for Waves, Coastal Currents, Inundation and Hydrologic Flooding for Eastern North Carolina," UN-UNC-CH, (\$209K OU)
490. R. Kolar, "A Coupled Regional-Coastal Ocean Model: HYCOM/CG-ADCIRC," DOD-NRL, (\$333K OU)
491. M. Xue, "Contribution to WRF Model Development by the Center for Analysis and Prediction of Storms," DOC-NOAA, \$821K
492. K. Marfurt, "Improving Geologic and Engineering Models of Midcontinent Fracture and Karst Modified Reservoirs Using 3-D Seismic Attributes," UKCRINC, (\$61K OU)
493. P. Attar, P. Vedula, "Novel, Optimal, Physics-based Reduced Order Models for Nonlinear Aeroelasticity," Advanced Dynamics, \$49K
494. S. Dhall, "Autonomous Data Partitioning using Data Mining for High Performance Computing," NSF, (\$125K OU)

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External Research Grants (cont'd)

- 495. M. Xue, K. Brewster, J. Gao, "Ensemble-based Data Assimilation for Tropical Storms, and Realtime 3DVAR Analysis for Initial Proof of 'Warn-on-Forecast' Concept: Collaborative Research between CAPS and NSSL," DOC-NOAA, \$100,000
- 496. M. Xue, "Contribution to Model Development and Enhancement Research Team by the Center for Analysis and Prediction of Storms," DOC-NOAA, \$620K
- 497. M. Xue, K. Brewster, "Ensemble-based Data Assimilation for Convective Storms and Hurricanes," DOC-NOAA, \$100,000
- 498. S. Schroeder, "Discovering Satellite Tobacco Mosaic Virus Structure," OCAST, \$85K
- 499. S. Schroeder, "Computational Advances Toward Predicting Encapsidated Viral RNA Structure," Pharmaceutical Research and Manufacturer's Association of America, \$60K
- 500. R. Kolar, "Outer Boundary Forcing for Texas Coastal Models," Texas Water Development Board, \$20K
- 501. K. Milton, "Collaborative Research: Quantum Vacuum Energy", NSF, \$250K
- 502. A. McGovern, "Developing Spatiotemporal Relational Models to Anticipate Tornado Formation," NSF, \$500K
- 503. Y. Kogan, "Midlatitude Aerosol-Cloud-Radiation Feedbacks in Marine Boundary Layer Clouds", ONR, \$638K
- 504. J. Straka, K. Kanak, Davies-Jones, "Challenges in understanding tornadogenesis and associated phenomena," NSF, \$854K (total), \$584K (OU)
- 505. Y. Hong, "Improvement of the NASA Global Hazard System and Implement Server-Africa," NASA, \$272K
- 506. J. Antonio, S. Lakshmivaran, H. Neeman, "Predictions of Atmospheric Dispersion of Chemical and Biological Contaminants in the Urban Canopy." Subcontract No. 1334/0974-01, Prime Agency DOD-ARO, Subcontract through Texas Tech University, Lubbock, TX, Sep. 29, 2000 to Nov. 3, 2001, \$75K
- 507. A. Striolo, "Electrolytes at Solid-Water Interfaces: Theoretical Studies for Practical Applications," OSRHE Nanotechnology, \$15K
- 508. D. Papavassiliou, "Turbulent transport in non-homogeneous turbulence," NSF, \$320K

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External Research Grants (cont'd)

- 509. K. Droegemeier et al., "Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere," NSF, \$17M (total), \$5.6M (OU)
- 510. K. Droegemeier et al., "Linked Environments for Atmospheric Discovery (LEAD)," NSF, \$11.25M (total), \$2.5M (OU)
- 511. M. Strauss, P. Skubic et al., "Oklahoma Center for High Energy Physics", DOE EPSCoR, \$3.4M (total), \$1.6M (OU)
- 512. M. Richman, A. White, V. Lakshmanan, V. DeBrunner, P. Skubic, "Real Time Mining of Integrated Weather Data," NSF, \$950K
- 513. D. Weber, K. Droegemeier, H. Neeman, "Modeling Environment for Atmospheric Discovery," NCSA, \$435K
- 514. H. Neeman, K. Droegemeier, K. Mish, D. Papavassiliou, P. Skubic, "Acquisition of an Itanium Cluster for Grid Computing," NSF, \$340K
- 515. J. Levit, D. Ebert (Purdue), C. Hansen (U Utah), "Advanced Weather Data Visualization," NSF, \$300K
- 516. D. Papavassiliou, "Turbulent Transport in Wall Turbulence," NSF, \$165K
- 517. L. Lee, J. Mullen (Worcester Polytechnic), H. Neeman, G.K. Newman, "Integration of High Performance Computing in Nanotechnology," NSF, \$400K
- 518. R. Wheeler, "Principal mode analysis and its application to polypeptide vibrations," NSF, \$385K
- 519. R. Kolar, J. Antonio, S. Dhall, S. Lakshmiarahan, "A Parallel, Baroclinic 3D Shallow Water Model," DoD - DEPSCoR (via ONR), \$312K
- 520. R. Luettich (UNC), R. Kolar, B. Vieux, J. Gourley, "The Center for Natural Disasters, Coastal Infrastructure, and Emergency Management," DHS, \$699K
- 521. D. Papavassiliou, M. Zaman, H. Neeman, "Integrated, Scalable MBS for Flow Through Porous Media," NSF, \$150K
- 522. Y. Wang, P. Mukherjee, "Wavelet based analysis of WMAP data," NASA, \$150K
- 523. E. Mansell, C. L. Ziegler, J. M. Straka, D. R. MacGorman, "Numerical modeling studies of storm electrification and lightning," \$605K

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External Research Grants (cont'd)

- 524. K. Brewster, J. Gao, F. Carr, W. Lapenta, G. Jedlovec, "Impact of the Assimilation of AIRS Soundings and AMSR-E Rainfall on Short Term Forecasts of Mesoscale Weather," NASA, \$458K
- 525. R. Wheeler, T. Click, "National Institutes of Health/Predocorral Fellowships for Students with Disabilities," NIH/NIGMS, \$80K
- 526. K. Pathasarathy, D. Papavassiliou, L. Lee, G. Newman, "Drag reduction using surface-attached polymer chains and nanotubes," ONR, \$730K
- 527. D. Papavassiliou, "Turbulent transport in non-homogeneous turbulence," NSF, \$320K
- 528. C. Doswell, D. Weber, H. Neeman, "A Study of Moist Deep Convection: Generation of Multiple Updrafts in Association with Mesoscale Forcing," NSF, \$430K
- 529. D. Papavassiliou, "Melt-Blowing: Advance modeling and experimental verification," NSF, \$321K
- 530. R. Kol,ar et al., "A Coupled Hydrodynamic/Hydrologic Model with Adaptive Gridding," ONR, \$595K
- 531. D. Papavassiliou, "Scalar Transport in Porous Media," ACS-PRF, \$80K
- 532. M. Xue, F. Carr, A. Shapiro, K. Brewster, J. Gao, "Research on Optimal Utilization and Impact of Water Vapor and Other High Resolution Observations in Storm-Scale QPF," NSF, \$880K.
- 533. J. Gao, K. Droegemeier, M. Xue, "On the Optimal Use of WSR-88D Doppler Radar Data for Variational Storm-Scale Data Assimilation," NSF, \$600K.
- 534. K. Mish, K. Muraleetharan, "Computational Modeling of Blast Loading on Bridges," OTC, \$125K
- 535. V. DeBrunner, L. DeBrunner, D. Baldwin, K. Mish, "Intelligent Bridge System," FHWA, \$3M
- 536. D. Papavassiliou, "Scalar Transport in Porous Media," ACS-PRF, \$80K
- 537. Y. Wang, P. Mukherjee, "Wavelet based analysis of WMAP data," NASA, \$150K
- 538. R. Wheeler et al., "Testing new methods for structure prediction and free energy calculations (Predocorral Fellowship for Students with Disabilities)," NIH/NIGMS, \$24K
- 539. L. White et al., "Modeling Studies in the Duke Forest Free-Air CO2 Enrichment (FACE) Program," DOE, \$730K

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External Research Grants (cont'd)

- 540. Neeman, Severini, "Cyberinfrastructure for Distributed Rapid Response to National Emergencies", NSF, \$132K
- 541. Neeman, Roe, Severini, Wu et al., "Cyberinfrastructure Education for Bioinformatics and Beyond," NSF, \$250K
- 542. K. Milton, C. Kao, "Non-perturbative Quantum Field Theory and Particle Theory Beyond the Standard Model," DOE, \$150K
- 543. J. Snow, "Oklahoma Center for High Energy Physics", DOE EPSCoR, \$3.4M (total), \$169K (LU)
- 544. M. Xue, F. Kong, "OSSE Experiments for airborne weather sensors," Boeing, \$90K
- 545. M. Xue, K. Brewster, J. Gao, A. Shapiro, "Storm-Scale Quantitative Precipitation Forecasting Using Advanced Data Assimilation Techniques: Methods, Impacts and Sensitivities," NSF, \$835K
- 546. Y. Kogan, D. Mechem, "Improvement in the cloud physics formulation in the U.S. Navy Coupled Ocean-Atmosphere Mesoscale Prediction System," ONR, \$889K
- 547. G. Zhang, M. Xue, P. Chilson, T. Schuur, "Improving Microphysics Parameterizations and Quantitative Precipitation Forecast through Optimal Use of Video Disdrometer, Profiler and Polarimetric Radar Observations," NSF, \$464K
- 548. T. Yu, M. Xue, M. Yeay, R. Palmer, S. Torres, M. Biggerstaff, "Meteorological Studies with the Phased Array Weather Radar and Data Assimilation using the Ensemble Kalman Filter," ONR/Defense EPSCOR/OK State Regents, \$560K
- 549. B. Wanner, T. Conway, et al., "Development of the www.EcoliCommunity.org Information Resource," NIH, \$1.5M (total), \$150K (OU)
- 550. T. Ibrahim et al., "A Demonstration of Low-Cost Reliable Wireless Sensor for Health Monitoring of a Precast Prestressed Concrete Bridge Girder," OK Transportation Center, \$80K
- 551. T. Ibrahim et al., "Micro-Neural Interface," OCAST, \$135K
- 552. J. Snow, "Langston University High Energy Physics," \$155K (LU)

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External Research Grants (cont'd)

- 553. L.M. Leslie, M.B. Richman, C. Doswell, "Detecting Synoptic-Scale Precursors Tornado Outbreaks," NSF, \$548K
- 554. L.M. Leslie, M.B. Richman, "Use of Kernel Methods in Data Selection and Thinning for Satellite Data Assimilation in NWP Models," NOAA, \$342K
- 555. J. Gao, K. Brewster, M. Xue, K. Droegemeier, "Assimilating Doppler Radar Data for Storm-Scale Numerical Prediction Using an Ensemble-based Variational Method," NSF, \$200K
- 556. E. Chesnokov, "Fracture Prediction Methodology Based On Surface Seismic Data," Devon Energy, \$1M
- 557. E. Chesnokov, "Scenario of Fracture Event Development in the Barnett Shale (Laboratory Measurements and Theoretical Investigation)," Devon Energy, \$1.3M
- 558. M. Xue, K. Brewster, J. Gao, "Study of Tornado and Tornadoic Thunderstorm Dynamics and Predictability through High-Resolution Simulation, Prediction and Advanced Data Assimilation," NSF, \$780K
- 559. A. Striolo, "Heat Transfer in Graphene-Oil Nanocomposites: A Molecular Understanding to Overcome Practical Barriers." ACS Petroleum Research Fund, \$40K
- 560. D.V. Papavassiliou, "Turbulent Transport in Anisotropic Velocity Fields," NSF, \$292.5K
- 561. D. Oliver, software license grant, \$1.5M
- 562. R. Broughton et al, "Assembling the Eutelost Tree of Life – Addressing the Major Unresolved Problem in Vertebrate Phylogeny," NSF, \$3M (\$654K to OU)
- 563. A. Fagg, "Development of a Bidirectional CNS Interface or Robotic Control," NIH, \$600K
- 564. M. Xue, J. Gao, "An Investigation on the Importance of Environmental Variability to Storm-scale Radar Data Assimilation," NSSL, \$72K
- 565. JV. Sikavistsas and D.V. Papavassiliou , "Flow Effects on Porous Scaffolds for Tissue Regeneration," NSF, \$400K
- 566. P. Skubic, M. Strauss, et al., "Experimental Physics Investigations Using Colliding Beam Detectors at Fermilab and the LHC," DOE, \$503K

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External Research Grants (cont'd)

- 567. Y. Wang, "Science for the Euclid Mission", NASA/JPL, \$52K (2020)
- 568. D. LaDue, K. Kloesel, "EPSCoR Funded Participant in the National Weather Center Research Experiences for Undergraduates Program," Oklahoma EPSCoR, \$9K
- 569. V. Sikavitsas, D. Papavassiliou, "The influence of fluid shear forces, oxygen and nutrient mass transport in the development of bone grafts in perfusion bioreactors," OCAST,, \$45K
- 570. D. Schmidtke, D. Papavassiliou, "Development of a Miniature Right Heart Support Device," NIH, \$347K
- 571. D. Resasco, D. Papavassiliou, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium, \$688K
- 572. B. L. Cheong, T.-Y. Yu, R. .D. Palmer, "Instrumental Support for the Winter Experiment Campaign," SELab Inc, \$215K
- 573. E. Bridge, "CAREER: Unwrapping the Migratory Gene Package," NSF, \$760K
- 574. E. Bridge, "The Electronic Transponder Analysis Gateway (ETAG): An Animal Behavior Observatory," NSF, \$315K
- 575. E. Bridge, "An Open-Source Radio Frequency Identification System for Animal Monitoring," NSF, \$331K
- 576. R. McPherson, E. White, M. Shafer, D. Rosendahl, M. Richman, "Trends in cold temperature extremes and winter weather for the SPTC region," USDOT, \$132K
- 577. R. Palmer, B. Cheong, C. Fulton, J. Salarzar, M. Yeary, T.-Y. Yu, Y. Zhang,. "Meeting the Technical Challenges of the Multi-Mission Phased Array Radar," NOAA, \$1.65M
- 578. M. J. McInerney, L. Krumholz, Bioremediation of Chromium and Arsenic from Industrial Wastewater," Nat'l Academies of Science, \$162K
- 579. M. Coniglio (PI), C. Doswell III, R. J. Trapp
- 580. "Improved understanding of convective-storm predictability and environment feedbacks from observations during the Mesoscale Predictability Experiment (MPEX)," NSF, \$272K
- 581. Y. Kogan, "Parameterization of Cumulus Convective Cloud Systems in Mesoscale Forecast Models," ONR, \$267K
- 582. S. Schroeder, "Predicting Viral RNA Structures, Function, and Drug Targets from Sequence," OCAST, \$145K

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External Research Grants (cont'd)

- 583. L. Ding, "NRI-Small: Robot Assistants for Promoting Crawling and Walking in Children at Risk of Cerebral Palsy," NSF, \$1.135M
- 584. E. Baron, "Collaborative Research: Three-Dimensional Simulations of Type Ia Supernovae Constraining Models with Observations," NSF, \$26K
- 585. H. Neeman, K. Brewster, A. McGovern, H. Severini, T. Yu, M. Atiquzzaman, G. Creager, B. George, Z. Gray, S. Radhakrishnan, P. Skubic, M. Strauss, X. Xiao, M. Xue, "A Model for Advanced Cyberinfrastructure Research and Education Facilitators," NSF, \$400K
- 586. E. Lemley, G. Qian, "MRI: Acquisition of a High Performance Computing Cluster for Research at a Predominantly Undergraduate Institution," NSF, \$305K
- 587. R. Floyd, J. Pei, "Understanding the Behavior of Prestressed Concrete Girders after Years of Service," OK DOT, \$327K
- 588. G. Zhang, S. Arani, "Polarimetric Phased Array Radar Research in Support for MPAR Strategy," NOAA, \$438K
- 589. A. Fierro, M. DeMaria, E. Mansell, C./ Ziegler, D. MacGorman, A. Schumacher, R. Brummer. "Using total lightning data from GLM/GOES-R to improve real-time tropical cyclone genesis and intensity forecasts," NOAA, \$268K (\$123K to OU)
- 590. U. Hansmann, "Folding, Mis-folding and Aggregation of Proteins," NIH, \$887K
- 591. G. R. Keller, S. Holloway, D. Devegowda, K. Crain, A. Holland, A. Ghassemi, "4D Integrated Study Using Geology, Geophysics, Reservoir Modeling and Rock Mechanics to Development Assessment Models for Potential Induced Seismicity Risk,," \$1.478M
- 592. J. Gao, D. Stensrud, X. Wang, "Assimilation of Doppler Radar Data with an Ensemble-based Variational Method for Storm-scale NWP," NSF, \$481K
- 593. M. Soe (RSU), "Unitary Qubit Lattice Algorithms for Quantum Turbulence with Non-Abelian Vortices," NSF, \$75K
- 594. J. Cruz, "Two-Dimensional Channel Modeling, Detection and Coding for Shingled Magnetic Recording," NSF, \$419K
- 595. J. Shaffer, "Laser Stabilization System for Rydberg Atom Physics," Army Research Office, \$75K

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External Research Grants (cont'd)

596. R. Sani (SDSMT), L. Krumholz, "Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep Environments (BuG ReMaDE)," NSF, \$6M (total), \$1.4M (OU)
597. A. Striolo (U College London), "Science 4 Clean Energy," European Commission, €12M (not to OU)
598. A. Striolo, D. Blankschtein, "Hydrates Growth and Coalescence: From Molecular Understanding to Useful Models," Royal Society, £12K (not to OU)
599. A. P. Khain (Hebrew U), A. V. Ryzhkov, "Coupling of polarimetric radar and cloud model," BSF, \$102K
600. A. V. Ryzhkov, A. P. Khain (Hebrew U), "Investigation of hazardous weather events using polarimetric radar and cloud model," BSF, \$111K
601. I. Jirak, H. Brooks, M. Pyle, "Information Extraction and Verification of Numerical Weather Prediction for Severe Weather Forecasting," NOAA, \$430K
602. I. Jirak, "Information Extraction and Verification of Convection-Allowing Models for Severe Hail Forecasting," NOAA, \$209K
603. I. Jirak, H. Brooks, M. Pyle, "Information Extraction and Verification of Convection-Allowing Models for Tornado Forecasting," NOAA, \$297K
604. X. Wang, "OU/WNI Collaborative Work on Assimilation of MURON and Himawari-8 Clear Sky Radiances to Improve Tropical Cyclone Forecast Over the West Pacific," WeatherNews Inc, \$136K
605. X. Wang, "GSI based Dual Resolution EnVar Data Assimilation for Convective-Scale 'Warn-on-Forecast'," NOAA, \$100K
606. X. Wang, "MPAR targeting observation research for WoF," NOAA, \$362K
607. X. Wang, A. Johnson, A. Clark, "Improving NWS Convection Allowing Hazardous Weather Ensemble Forecasts through Optimizing Multi-Scale Initial Condition (IC) Perturbations," NOAA, \$277K
608. X. Wang, A. Johnson, T. Jones, "Assimilation of high resolution GOES-R ABI infrared water vapor and cloud sensitive radiances using the GSI-based hybrid ensemble-variational data assimilation system to improve convection initiation forecast," NOAA, \$368K
609. X. Wang, "Further Advancement of HWRF Self-Consistent Ensemble-Variational Hybrid Data Assimilation System to Improve High Resolution Hurricane Vortex Initialization," NOAA, \$377K

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610. X. Wang, "Advancing the Assimilation of Airborne Hurricane Observations using the GSI-based Hybrid Ensemble-Variational Data Assimilation System for HWRF," NOAA, \$294K
611. X. Wang, L. Leslie, "Understanding the Impact of Outflow on Hurricane Intensification through Ensemble-based Data Assimilation and Ensemble Simulation with Multiple Models," ONR, \$376K
612. J. P. Shaffer, "Atom Surface Interactions and Hybrid Quantum Systems for Quantum Engineering Applications," AFOSR, \$750K
613. J. P. Shaffer, "SBIR," DARPA-SBIR, \$15K
614. J. P. Shaffer, "High Sensitivity Absolute Electric Field Sensing with Atoms," NRO, \$309K
615. J. P. Shaffer, "US -Brazil Professorship and Lectureship," American Physical Society, \$4K
616. J. P. Shaffer, "Control of Rydberg Interactions and Exotic States of Matter," NSF, \$473K
617. L. Ding, "Neurophysiological Assessment of Thresholds of Audibility and Loudness in Healthy Persons and Cochlear Implants Users," Hearts for Hearing, \$100K
618. D. Myers (ECU), C. Crittall (ECU), "STEM-Double Bridge," NSF via UCO, \$335K
619. B. Moore, S. Crowell, "(EVM-2) The geoCARB Mission, NASA, \$161M (total), \$39M (OU)
620. M. Kaspari, C. Siler, M. Weiser, K. Marshall, M. Miller, "Testing abiotic drivers of activity, abundance, and diversity of ground-dwelling arthropod communities at a continental scale," NSF, \$1.5M
621. T. Gamble (Marquette U), C. Siler (OU), J. Daza (Sam Houston State U), M. Heinicke (U Michiga - Dearborn), "From Exaptation to Key Innovation - Evolutionary Insights from Gliding Geckos," NSF, \$1.1M (total), \$323K (OU)
622. F. Kong, M. Xue, K. Brewster, X. Hu, "Development of a Storm-Scale Ensemble Numerical Weather Prediction System for Chongqing Meteorological Service," Chongqing Inst of Green & Intelligent Tech, Chinese Academy of Sciences, \$643K
623. K. Brewster, X. Wang, F. Carr, "Prototyping and Evaluating Key Network-of-Networks Technologies," NOAA, \$192K
624. B. Moore, K. Brewster, F. Carr, "CASA DFW Testbed Operations and Data Impacts," Global Science Technology, \$97K

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External Research Grants (cont'd)

625. M. Xue, X. Hu, Y. Jung, K. Brewster, "Assessment and Optimization of YSU-Type Non-Local PBL Scheme for the Prediction of Day- and Night-Time Storm Environment and Tornadoic Storms during VORTEX-SE," NOAA, \$3M
626. M. Xue, N. Snook, K. Brewster, Y. Jung, F. Kong, "A Partnership to Develop and Evaluate Optimized Realtime Convective-Scale Ensemble Data Assimilation and Prediction Systems for Hazardous Weather: Toward the Goals of a Weather-Ready Nation," NOAA. \$450K
627. M. Xue, K. Brewster, Y. Jung, F. Kong, "A Partnership to Develop, Conduct, and Evaluate Realtime Advanced Data Assimilation and High-Resolution Ensemble and Deterministic Forecasts for Convective-scale Hazardous Weather: Towards the Goals of Weather Ready Nation," NOAA, \$375K
628. y. Jung, M. Xue, G. Zhang, "Development of a Polarimetric Radar Data Simulator for KLAPS," IN-KMA, \$188K
629. K. Brewster, F. Carr, X. Wang, "Prototyping and Evaluating Key Network-of-Networks Technologies: Project Extension," ?, \$192K
630. B. Moore, M. Xue, A. Bamzai, R. McPherson, "Very-high resolution dynamic downscaling of regional climate for use in long-term hydrologic planning along the red river valley system," DOI-USG, \$127K
631. X. Hu, "Collaborative Research: Studies of Chlorine, Bromine and Iodine Chemistry in the Arctic, and its Impacts," NSF/U Michigan, \$47K
632. N. Snook, M. Xue, Y. Jung, A. McGovern, "Development and Implementation of Ensemble Hail Forecast Products using Multi-moment Microphysics and Machine Learning Algorithms," NOAA, \$335K
633. B. Moore, X. Hu, M. Xue, "Atmospheric Carbon and Transport – America," NASA, \$168K
634. M. Xue, G. Zhang, "Assessment of the Performance of Beijing Meteorological Service (BMS) X-band Polarimetric Radars and Data Quality Control and Assimilation for the BMS X-band Radar Network," IN-BMS, \$120K
635. M. Xue, F. Kong, Y. Jung, C. Liu, "Development and Optimization of Radar-Assimilating Ensemble-Based Data Assimilation for Storm-Scale Ensemble Prediction in Support of HWT Spring Experiments," NOAA, \$291K

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External Research Grants (cont'd)

- 636. M. Xue, F. Kong, K. Brewster, N. Snook, “Convection-Allowing Ensemble Prediction for Heavy Precipitation in Support of the Hydrometeorology Testbed (HMT): New QPF Products, Data Assimilation Techniques and Prediction Model,” NOAA, \$290K
- 637. M. Xue, Y. Jung, F. Kong, K. Brewster, “Enhancement and Evaluation of NGGPS Model FV3 at Convection-Allowing Resolutions through Hazardous Weather Testbed Spring Experiment towards Accelerated Operational Implementation of FV3 for Mesoscale Applications,” NOAA, 194K
- 638. M. Xue, Y. Jung, “Advanced Data Assimilation and Prediction Research for Convective-Scale ‘Warn-on-Forecast,’” NOAA, \$208K
- 639. L. Gruenwald, “Cost- and Energy-Aware Spatio-Temporal Query Processing in Mobile Clouds,” NSF, \$200K
- 640. T. Neeson, H. Moreno, “A Return on Investment Approach to Restoring Natural Flow Regimes in the Red River,” Great Plains Landscape Conservation Cooperative, \$195K
- 641. T. Neeson, H. Moreno, “Balancing water usage and ecosystem outcomes under drought and climate change: enhancing an optimization model for the Red River, USGS-SCCSC, \$213K
- 642. D. K. Walters, “Implementation and Validation of Advanced Turbulence Modeling Methods for Liquid Metal Flow in Nek5000,” DOE, \$756K
- 643. D. K. Walters, “Multiphysics Simulations of Multi-Component, Off-Design Aircraft Engine Operation Using Dynamic Hybrid RANS/LES,” DoD HPC Modernization Program, \$164K
- 644. X. Chen, “Rapid Response for the M5.1 Fairview Earthquake - Detailed Understanding of the Fault Systems in Western Oklahoma,” NSF, \$14K
- 645. J. Zhao, L. Xiang, “Photoacoustic Imaging of Myeloproliferative Neoplasms and Associated Vascular Complications,” PHF Team Science, \$100K
- 646. L. Xiang, K. Stratton, “Photoacoustic Imaging for Prostate Cancer Detection,” OU COE, \$10K
- 647. J. Suflita, K. Duncan, J. Sunner, I. Davidova, “Managing Microbial Corrosion in Canadian Offshore & Onshore Oil Production Operations,” U Calgary, \$363K

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External Research Grants (cont'd)

648. A. Ryzhkov (OU), A. Khain (Hebrew U), M. Kumjian (Penn State U), "Investigations of Microphysical Processes in Clouds Using Spectral Cloud Models Coupled with Polarimetric Radar Measurements at Multiple Frequencies," DOE, \$431K (total), \$231K (OU)
649. A. Ryzhkov (OU), A. Khain (Hebrew U), "Microphysical and Thermodynamic Retrievals in Deep Convective Clouds Using Polarimetric Radar Measurements and Spectral Cloud Models with Explicit Treatment of Aerosol Impact on Convective Processes," DOE, \$433K (total), \$230K (OU)
650. K. Duncan, J. Suflita, R. Tanner, "BHP/Nalco/OU MIC Project," bhpBilliton, \$310K
651. K. Duncan, B. Wawrik, J. Suflita, "Amendment 2 to the Research Agreement FR00008538, Primer Validation and Design Project and RPA Project," TOTAL S.A, \$95K
652. W. Freeman, A. Richardson, "High throughput single cell analysis of hippocampus with Alzheimer's Disease," National Institute on Aging, \$148K
653. X. Wang, D. Parsons, D. Stensrud, "Improving the Understanding and Prediction of Nocturnal Convection through Advance Data Assimilation and Ensemble Simulation in PECAN," NSF, \$708K
654. D. Parsons, H. Bluestein, "Investigation into the mechanisms for the maintenance of nocturnal convective systems," NSF, \$599K
655. L. Bumm, L. Huang, "Advanced Real-Space Measurements with STM: Application to Molecular Monolayers, Monolayer Defects, and Surface Chemistry," NSF, \$442K
656. F. Kong, K. Brewster, X. Hu, M. Xue, "Development of a Storm-Scale Ensemble Numerical Weather Prediction System for Chongqing Meteorological Service," Chongqing Inst of Green and Intelligent Tech, Chinese Academy of Sciences, \$212K
657. N. Nakata, "Ambient Field Analysis of Earthquake Ground Motion at Groningen Gas Field, Stanford University & Shell Oil Company, \$47K
658. B. Moore III, K. Brewster, F. Carr, B. Illston, K. Kloesel, "National Mesonet Program," Earth Networks Inc. & Stinger Ghaffarian Technologies, \$446K
659. D. K. Walters, "Aerodynamic Flow Deflector for Current and Future Wind Turbines to Increase the Annual Energy Production by 10% and Reduce the Levelized Cost of Energy by 8%," XPEED Turbine Technology & NSF, \$131K

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External Research Grants (cont'd)

- 660. P. Skubic, B. Abbott, P. Gutierrez, M. Strauss, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center," U Texas Arlington, \$30K
- 661. S. Schroeder, "Metal Ion Interactions in RNA Shapeshifters," Burroughs Wellcome Fund Collaborative Research Travel Grant, \$9K
- 662. E. Baron, "Modeling the Atmosphere of Solar and Other Stars Radiative Transfer with PHOENIX/3D," NASA, \$478K
- 663. U. Hansmann, "Efficient and Accurate Force Fields for Computer-Aided-Drug Design," U Arkansas/NIH, \$73K
- 664. C.-H. Lee, "Computer-Assisted Management and Treatment of Functional Tricuspid Regurgitation," American Heart Association, \$30K
- 665. C. Lewis, P. Lawson, C. Warinner, "Microbial Ecologies of Indigenous Communities," NIH, \$743K
- 666. J. Ruyle, E. Bridge, M. Stacy, "Collaborative Research: IDBR: Type B: An Open-Source Radio Frequency Identification System for Animal Monitoring (NonDeclination; routing ATF)," NSF, \$344K
- 667. X. Wang, "Further Advancement of HWRF Self-Consistent Ensemble-Variational Hybrid Data Assimilation System to Improve High Resolution Hurricane Vortex Initialization," NOAA, \$292K
- 668. X. Wang, "Development of NWS convective scale ensemble forecasting capability through improving GSI-based hybrid ensemble-variational data assimilation and evaluating multi-dynamic core approach," NOAA, \$449K
- 669. B. Holt, "NF-Y Transcription Factor Roles in Far Red Light Signaling - A First Look," OCAST, \$100K
- 670. M. Xue, Y. Jung, "Advanced Data Assimilation and Prediction Research for Convective-Scale ...," NOAA, \$200K
- 671. S. Cavallo, "Polar predictability and dynamics through multi-scale atmospheric vortices," DOD-ONR, \$105K
- 672. G. Richter-Addo, "Redox Behavior and Chemical Reactivity of Heme-HNOx Complexes," NSF, \$516K
- 673. J. Suflita, K. Duncan, J. Sunner, B. Wawrik, "Continued Studies of the OUBC with Total," Total S.A., \$222K

OSCER-FACILITATED FUNDING TO DATE:

\$824M total, \$375M to OU



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External Research Grants (cont'd)

- 674. M. Xue, K. Brewster, N. Snook, Y. Jung, F. Kong, "A Partnership to Develop and Evaluate Optimized Realtime, Convective-Scale Ensemble Data Assimilation and Prediction, Systems for Hazardous Weather: Toward the Goals of a Weather-Ready Nation," NOAA, \$450K
- 675. J. Abbas, S. Huskey, C. Weaver, "Digital Latin Library Implementation," Andrew Mellon Foundation, \$1M
- 676. C. Warinner, C. Lewis, K. Sankaranarayanan, "Evolution and Ecology of the Human Oral Microbiome," NSF, \$101K
- 677. T. Fritz, C. Miller, R. Munoz, C. Hellman, "Oklahoma SBIRT Training Collaborative," Health and Human Services, Substance Abuse Mental Health Services Admin, \$622K
- 678. D. Bodine, A. Reinhart, "Exploration of Terrain Effects, on Tornado and Supercell Dynamics in the Southeast United States," NOAA, \$192K
- 679. N. Kaib, "Numerical Studies of the Dynamical Interplay Between the Inner and Outer Planets," NSF, \$227K
- 680. N. Kaib, "The Influence of Stellar Companions on Fomalhaut's Planetary System, NASA, \$59K
- 681. N. Kaib, "Exploring the Evolution and Characterizing the Chaos of the Terrestrial Planets," U Illinois at Urbana-Champaign Blue Waters Grad Fellowship, \$50K
- 682. A. Shapiro, C. Potvin, "Improving vertical velocity retrievals from Doppler radar observations of convection," NSF, \$599K
- 683. M. Richman, L. Leslie, C. Doswell, "Objective Probabilistic Guidance for Severe Weather Outbreaks," NOAA, \$51K
- 684. M. Nanny, C. Mao, P. Hardre, S. Wu, A. Burgett, U. Hansmann,
- 685. L. Krumholz, S. Liu, L. Bartley, "RET Site: Rural Educators Engaged in Bioanalytical Engineering Research and Teaching," NSF, \$600K

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External Funding Summary

- External research funding facilitated by OSCER
(Fall 2001- Fall 2020): **\$824M total, \$375M to OU** (46%)
- Funded projects: **680+**
- **260+** OU faculty and staff in **36** academic departments and **13** non-academic units
- Comparison: Fiscal Year 2002-20 (July 2001 – June 2020):
OU Norman externally funded research expenditure: \$1.74B

Since being founded in fall of 2001,
OSCER has enabled research projects comprising
over 1 / 5 of OU Norman's total externally funded research expenditure, with more than a **10-to-1 return on investment**.



OSCER Users vs Non-Users @ OU Norman #1

During FY2016-20, among OU Norman PIs credited with external research expenditure, OSCER users (and advisors of OSCER users) were credited with 2.7 times as much median annual expenditure as non-users of OSCER:

- OSCER users @ OU Norman: median \$89,318.20/year
- OSCER non-users @ OU Norman: median \$33,160.30/year
(Based on analysis of VPRP's PI annual research expenditure spreadsheets FY2016-20.)



OSCER Users vs Non-Users @ OU Norman #2

NOTES

- The real disparity is probably far more than 2.7x, because:
 - **185** of 209 (**89%**) of OSCER-user PIs at OU Norman had external research expenditure in FY2016-20;
 - **688** OU Norman non-OSCER-users had external research expenditure, out of an estimated 2-4000, based on fall 2019's potential research PIs (2002 full- and part-time faculty, and 1980 full- and part-time support/service professional staff).
 - So, 17-34% of non-OSCER users vs 89% of OSCER users.
- We make no claims about causality (existence or direction) – we only note the disparity between these two populations.



Publications Facilitated by Research IT

- Publications facilitated by Research IT resources

- **2020: 249 (so far)**

- 2019: 297

- 2018: 313

- 2017: 225

- 2016: 277

- 2015: 224

- 2014: 212

- 2013: 248

- 2012: 280

- 2011: 182

- 2010: 139

- 2009: 108

- 2008: 112

- 2007: 77

- 2006: 96

- 2005: 71

- 2004: 32

- 2003: 12

- 2002: 10

- 2001: 3

TOTAL SO FAR: 3167 publications

<http://www.oscer.ou.edu/publications/>

Includes 85 PhD dissertations, 83 MS theses.



Top 10 OU Research Teams FY2020

1. High Energy Physics: 18.7M core-hours
2. Meteorology: PI X. Wang: 5.4M core-hours
3. Center for Analysis & Prediction of Storms: 4.2M core-hours
4. Petroleum & Geological Engr: PI A. Ghassemi: 3.7M core-hours
5. Chemistry & Biochemistry: PI Y. Shao: 3.6M core-hours*
6. Chemistry & Biochemistry: PI U. Hansmann: 3.4M core-hours
7. Aerospace & Mechanical Engr: PI D. K. Walters: 2.9M core-hours
8. Chemical, Biological & Materials Engr: PI L. Huang: 2.6M core-hours
9. Aerospace & Mechanical Engr: PI J. Garg: 2.2M core-hours*
10. Computer Science: PI A. McGovern: 1.7M core-hours

* Asst Prof



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How Did We Get This Data?

- We e-mailed hundreds of faculty, staff, postdocs and students, and asked them to send us whatever they had new.
 - For each one, we gave them the list of grants and publications of theirs that we already had.
 - The labor cost was on the order of 40 hours.
- We also asked OU Research Services for all 2019-20 new grants that had pressed the OSCER button on the web form for starting the internal paperwork for a new proposal.



NSF AI Research Institute

- A team led by Prof. Amy McGovern of OU CS has been awarded a 5-year, \$20M NSF AI Research Institute grant to study the use of AI/Machine Learning for environmental sciences.
- OSCER will be running the computing component.



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OU Meteorology NASA Projects

- The Director of OU Meteorology and his team have done multiple large scale projects for NASA, suddenly needing lots of CPU cores for weeks at a time.
- They bought some condominium nodes, and we lent them the rest.
- These projects are typically mid 5 figures to low 6 figures of single-core jobs, several hours each.



Events Hosted in the Past Year

- Virtual Residency Intro/Intermediate workshop 2020
 - 430 attendees!
- Oklahoma Supercomputing Symposium 2020



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Ongoing, Current and New Initiatives



Virtual Residency

- “Everyone complains about the weather, but no one ever does anything about it.”
- We created a program to teach people how to be research computing facilitators, and ultimately to be institutional CI leaders.
- No one had ever been dumb enough to try to teach this until we decided to.
- Workshops: Introductory 2015, 2016, 2017; Intermediate/Advanced 2018; Introductory/Intermediate 2019; **Intermediate/Advanced 2020**
- Regular conference calls
- Grant Proposal Writing Apprenticeship (2017-18, 18-19, 19-20)
- Paper Writing Apprenticeship (2018-19: PEARC’ 19, ’20 paper)



Virtual Residency Program

- The Virtual Residency Program has now taught 924 people from 370 institutions in every US state plus 3 US territories and 11 other countries on 5 continents, including
 - 56 Minority Serving Institutions (15% of VRP institutions);
 - 94 non-PhD-granting institutions (25%);
 - 101 institutions (27%) in 27 of 28 EPSCoR jurisdictions (all except Guam);
 - 243 of 327 Campus Champion institutions (66% of VPR institutions, 74% of Campus Champion institutions);
 - 119 of 114 Campus Research Computing Consortium (CaRCC) (32% of VRP institutions, 84% of CaRCC institutions);
 - 121 R1 institutions (33% of VPR institutions, 93% of R1s).



**Lead, Follow
or Get Out of the Way**

Taking Leadership

- Statewide
- Regional
- National



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Statewide Leadership Examples

The OneOklahoma Cyberinfrastructure Initiative (OneOCII) is a volunteer, ad hoc collaboration among CI providers and users across our state.

- We've grown to 6 CI providers.
- We're on e-mail multiple times a week and on a weekly phone call every Tuesday at 4:00pm CT, working together on a wide variety of projects.
- It's helped us get CI grants, start a statewide HPC contest, help each other help our researchers, and so much more.
- We've got a OneOCII panel today at 4pm Central Time.



Regional Leadership Examples

- Within the Great Plains region, we've been building our leadership across the 6 member states of the Great Plains Network (Arkansas, Kansas, Missouri, Nebraska, Oklahoma and South Dakota).
- Our former OneNet CTO is now the GPN Executive Director.
- The GPN institutions have been awarded two NSF CC* grants: a CC* Cyber Team grant and a CC* Compute grant.



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National Leadership Examples

- OneOCII institutional CI leads have, or have had, the following leadership roles:
 - XSEDE Campus Engagement joint co-managers (the umbrella over Campus Champions)
 - Founded the Virtual Residency Program
 - Linux Clusters Institute steering committee
 - SC10-11 Education Program leadership
 - NSF Advisory Committee for Cyberinfrastructure



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- Grant No. EPS-1006919, “Oklahoma Optical Initiative”
- Grant No. OCI-1039829, “MRI: Acquisition of Extensible Petascale Storage for Data Intensive Research”
- Grant No. OCI-1126330, “Acquisition of a High Performance Compute Cluster for Multidisciplinary Research”
- Grant No. ACI- 1229107, “Acquisition of a High Performance Computing Cluster for Research and Education”
- Grant No. EPS-1301789, “Adapting Socio-ecological Systems to Increased Climate Variability”
- Grant No. ACI-1341028, “OneOklahoma Friction Free Network”
- Grant No. ACI-1429702, “Acquisition of a High Performance Computing Cluster for Research at a Predominantly Undergraduate Institution”
- Grant No. ACI-1440774, “Leveraging Partnerships Across the Great Plains to Build Advanced Networking and CI Expertise”
- Grant No. ACI-1440783, “A Model for Advanced Cyberinfrastructure Research and Education Facilitators”
- Grant No. OAC-1828567, “MRI: Acquisition of a Regional Resource for Long-term Archiving of Large Scale Research Data Collections,” OU, \$968K



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Symposium 2004-19 Sponsors: Thank You!

- Sponsors: 98 commercial, 7 non-commercial

Thank you all! Without you, past Symposia couldn't happen.

Of our 98 commercial sponsors, half have repeated (and/or were acquired by or merged with other sponsors).



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Thanks!

- OU IT
 - OU CIO David Horton
 - OSCER Operations Team: Dave Akin, Patrick Calhoun, Kali McLennan, Jason Speckman
 - OSCER Research Computing Facilitators: Jim Ferguson, Horst Severini
 - Jeremy Hessman, OU IT, for Zoom license help
 - All of the OU IT folks who helped put this together
- OneOklahoma Cyberinfrastructure Initiative (OneOCII)
 - Pratul Agarwal, OSU
 - Stephen Wheat, ORU



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- Amy Friedlander, National Science Foundation
- Susan Gregurick, National Institutes of Health
- Tom Lange, Technology Optimization & Management LLC
- John Shalf, Lawrence Berkeley National Laboratory
- Dan Stanzione, Texas Advanced Computing Center, University of Texas at Austin



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Thanks: Panel

- Moderator: James Deaton, Great Plains Network
- Pratul Agarwal, Oklahoma State U
- Brian Burkhardt, OneNet
- Jeremy Evert, Southwestern Oklahoma State U
- Jim Ferguson, OU
- Karl Frinkle, Southeastern Oklahoma State U
- Peter Hawrylak, U Tulsa
- Evan Lemley, U Central Oklahoma
- Stephen Wheat, Oral Roberts U



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Thanks!

To all of you for participating, and to those many of you who've shown us so much loyalty over the past 18 years.



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To Learn More

<http://www.oscer.ou.edu/>

<http://oneocii.okeyscores.org/>



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**Thanks for your
attention!**

Questions?

Henry Neeman, PI

Cyberinfrastructure Leadership Academy

University of Oklahoma

Norman, Oklahoma

<http://www.oscer.ou.edu/>

hneeman@ou.edu



- **Senior Cyberinfrastructure leaders** are retiring and taking their knowledge, experience and wisdom with them. We need to capture this quickly.
- **Emerging midcareer CI leaders** are excellent at responding to national needs and serving their institutions' researchers, but need to learn how to **shape the national CI agenda**.
- **Goals** of this workshop in **bringing these two groups together**:
 - **Transfer knowledge, experience and especially wisdom** from senior CI leaders to emerging CI leaders, in order to enable emerging CI leaders to shape the national research CI landscape.
 - **Initiate mentoring relationships** between senior CI leaders and emerging CI leaders, in order to foster longer term professional development.
 - **Establish peer mentoring** among emerging CI leaders, in order to prepare and position them for national leadership, as senior CI leaders reduce their day to day engagement.
- **National Strategic Computing Initiative**: This workshop focus is a key aspect of the NSF's **workforce development** mission within NSCI.

**A Business Model
for Physical Management of
Big Data**

Business Model

OURRstore

- **Grant**: hardware, software, multi-year extended warranties on everything
- **Institution (CIO)**: space, power, cooling, labor, maintenance after the initial extended warranty period
- **Researchers**: media (tape cartridges)
- Compared to roll-your-own disk, for researchers OURRstore tape is:
 - cheaper
 - more reliable
 - less labor
 - requires less training (~1 hour)
 - slower (moderate bandwidth, very high latency)



OURRstore Technology Strategy

- Distribute the costs among a research funding agency, the institution, and the research teams.
- Archive, not live storage: “Write once, read seldom if ever.”
- Independent, standalone system; not part of a cluster.
- Spend grant funds on many slots but few tape cartridges.
- Media slots are available on a first come first serve basis.*
- Software cost should be a modest fraction of total cost.
- Maximize media longevity.
- Globus for file transfers, file sharing, file publishing, discoverability etc.
- LTFS (tiny file catalog on each tape cartridge):
Ship secondary copies to the data owner --
if anything goes wrong, it’s under \$3K to buy
an LTO tape drive, and the software is free.



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NSF MRI Grant

“MRI: Acquisition of a Regional Resource for Long-term Archiving of Large Scale Research Data Collections”

National Science Foundation grant no. OAC-1828567

9/1/2020 - 8/31/2021

Grant is 3 years -- archive is 8+ years.



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Who's Eligible? Who's In?

- Institutions in Great Plains Network states (AR,KS,MO,NE,OK,SD)
- Institutions in EPSCoR jurisdictions
- Institutions (and consortia) in non-EPSCoR jurisdictions, if they buy an expansion cabinet
- So far, 85 research teams at 27 institutions in 17 states, including 27 research teams at OU.
 - Just voted to start actively recruiting more!
- 16 teams will each need at least 1 PB: 8 at OU, 1 in another GPN state, and 7 in non-GPN EPSCoR states. By contrast, the original PetaStore proposal included only 12 teams *total*, regardless of capacity need.



How Much Need?

Per the proposal:

- Capacity needed: 134 PB
 - \$25M+ in on-premise RAID, OR
 - \$15M+ in cloud, OR,
 - \$8M in USB disk drives (Good luck managing that!), OR
 - \$2.4M in tape cartridges
 - If we bought the full 134 PB today.
- Current funding of these projects: \$162M
- Pending/planned funding: \$140M
- Faculty: 250+
- Staff: 150+
- Postdocs: 100+
- Graduate students: 500+
- Undergraduate students: 500+



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Yeah, But Tape Sucks!

- Well, yes, tape does suck:
 - Retrieval has very high latency (typically 1 minute per file).
 - Tape medium inside a tape cartridge can break!
- How to resolve?
 - Only store large files (OURRstore minimum is 1 GB).
 - So, you have to create Zip files or compressed tar files.
 - Offline storage: download file to disk before using.
 - Think hierarchically:
 - Small amount of very fast disk
 - Medium amount of “slow” disk
 - Large amount of tape



Investment Protection

- PetaStore (current archive) will reach end-of-life when OURRStore gets to full production.
- Faculty may not have funds for purchasing new media in the next archive for their old data (that's not relevant to their current grants).
- Need to provide for buying up front instead of recurring charges.
- How to handle the tape?



Longevity Strategy

- OURRstore has to be backward-compatible with the PetaStore, in the sense of allowing LTO, including LTO-5 and LTO-6.
 - Tape cartridges are good for the earliest of:
 - 15 years
 - 5000 load/unload cycles
 - 200 complete tape read/writes
 - So far, only 6 PetaStore tape cartridges ($\ll 1\%$) are in danger of wearing out in less than 15 years.
- OURRstore must include some LTO-6 drives, which can read and write both LTO-6 and LTO-5, but new tapes will be LTO-7 Type M (9 TB).
- Unlike disk drives, tape cartridges can migrate from system to system.



Longevity Mechanism

Once OURRstore is in full production:

- Set PetaStore to read-only.
- On the PetaStore, for a small number of tape cartridges, identify all the files on them.
- Copy all those tape cartridges to OURRstore.
- Export those tape cartridges from the PetaStore.
- Import them into OURRstore and reformat.
- Repeat, copying the new files onto the newly imported cartridges.
- When all files are copied (months, maybe a year), decommission the PetaStore.

We'll use this same procedure at OURRstore's end of life.



Schooner: non-condominium nodes

- Compute nodes, non-condominium, Haswell
 - 266 x R430, dual E5-2650v3 10-core 2.3/2.0/2.6 GHz, 32 GB RAM
 - 72 x R430, dual E5-2660v3 10-core 2.6/2.2/2.9 GHz, 32 GB RAM
 - 48 x R430, dual E5-2670v3 12-core 2.3/2.0/2.6 GHz, 64 GB RAM
- Accelerator-capable nodes, non-condominium, Haswell
 - 28 x R730, dual E5-2650v3 10-core 2.3/2.0/2.6 GHz, 32 GB RAM
 - 5 x R730, dual E5-2670v3 12-core 2.3/2.0/2.6 GHz, 64 GB RAM
- Large RAM node, non-condominium, Haswell
 - 1 x R930, quad E7-4809v3 8-core 2.0/1.8/1.8 GHz, 1024 GB RAM
- Accelerators, non-condominium
 - 6 x NVIDIA K20M
 - 24 x Intel Xeon Phi 31S1P
- Subtotal peak CPU speed, non-condominium:
280.47 TFLOPs (base), 365.26 TFLOPs (max turbo)

Schooner: Condominium, Haswell/Broadwell

■ Compute nodes, condominium, Haswell/Broadwell

- 7 x R630, dual E5-2640v3 8-core 2.6/2.2/2.8 GHz, 32 GB RAM
- 6 x R430, dual E5-2650Lv3 12-core 1.8/1.5/2.1 GHz, 64 GB RAM
- 84 x R430, dual E5-2670v3 12-core 2.3/2.0/2.6 GHz, 64 GB RAM
- 5 x R430, dual E5-2670v3, 12-core 2.3/2.0/2.6 GHz, 128 GB RAM
- 14 x R430, dual E5-2650v4 12-core 2.2/1.8/2.8 GHz, 64 GB RAM
- 6 x R730, dual E5-2630v3, 8-core 2.4/2.1/2.6 GHz, 128 GB RAM

■ Accelerator-capable nodes, condominium, Haswell

- 1 x R730, dual E5-2650v3 10-core 2.3/2.0/2.6 GHz, 32 GB RAM
- 3 x R730, dual E5-2670v3 12-core 2.3/2.0/2.6 GHz, 64 GB RAM

■ Large RAM node, condominium, Haswell/Broadwell

- 1 x R930, quad E7-4809v3 8-core 2.0/1.8/1.8 GHz, 3072 GB RAM
- 1 x R930, quad E7-4830v4 14-core 2.0/1.6/2.2 GHz, 2048 GB RAM

■ Accelerators

- 8 x NVIDIA K20M

■ Subtotal peak CPU speed, new condominium:

93.95 TFLOPs (base), 124.29 TFLOPs (max turbo)

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Schooner: Condominium, Skylake/Cascade Lake/KNL

- Compute nodes, condominium, Skylake/Cascade Lake
 - 12 x R640, dual Gold 6140 18-core 2.3/1.5/2.1 GHz, 96 GB RAM
 - 1 x R640, dual Gold 6152 22-core 1.8/1.5/2.1 GHz, 384 GB RAM
 - 4 x R640, dual Gold 6230 12-core 2.1/1.1/2.0 GHz, 96 GB RAM
 - 5 x R440, dual Gold 6230 12-core 2.1/1.1/2.0 GHz, 192 GB RAM
 - 4 x R440, dual Gold 6230 12-core 2.1/1.1/2.0 GHz, 96 GB RAM
- Compute nodes, condominium, Intel Xeon Phi Knights Landing
 - 5 x C6320p, sgl 7210, 64-core 1.3/1.5 GHz, 48 GB RAM
 - 3 x C6230p, sgl 7230, 64-core 1.3/1.5 GHz, 48 GB RAM
- Subtotal peak CPU speed, condominium
Skylake/Cascade Lake/KNL:
62.31 TFLOPs (base), 76.53 TFLOPs (max turbo)

Schooner: Condominium, Sandy Bridge

As an experiment, we transferred condominium nodes from Boomer over to Schooner. This worked great!

- Compute nodes, condominium, old
 - 59 x R620, dual E5-2650 [v1], 8-core, 2.0 GHz, 32 GB
- Accelerator-capable nodes, condominium, old
 - 6 x R720, dual E5-2650 [v1], 8-core, 2.0 GHz, 32 GB
- Accelerators, condominium, old
 - 12 x NVIDIA M2075
 - 6 x NVIDIA K20M
- Storage, diskfull nodes, condominium, old
 - 4 x R720xd, 12 x 3 TB = ~19 TB usable each
- Subtotal peak CPU speed, old condominium: 16.64 TFLOPs

Schooner: non-condominium other

- Interconnects
 - Infiniband: Mellanox FDR/FDR10 3:1 oversubscribed (40 Gbps native, 13.33 Gbps oversubscribed)
 - Ethernet: GigE downlinks to nodes, 10GE uplinks to core
- Storage (user-accessible)
 - DataDirect Networks SFA7700X Lustre w/70 x 6 TB = ~309 TB usable
 - 7 x home/scratch/work/data 12 x 6 TB = ~176 TB usable



New Supercomputer Features

- **NEW! Long job queue (7 days)**
- **NEW! Daily report on queue wait times**
- **COMING! Unlimited job durations**
(If we can get batch job preemption/suspension to work)
- **COMING! Core and RAM request enforcement via cgroups**



New Initiatives

- **GPU Needs Analysis**: We want to know who is likely to need GPUs for their number crunching, including but not limited to AI/Machine Learning/Deep Learning.
- **Single-node/Multi-thread Benchmarking**: For researchers who run single-node/multi-threaded parallel applications, we want to work with them, to benchmark their software to see what the best number of threads to run on is. This is very important because the next generation of CPUs have up to 128 cores per CPU chip! So if your code runs best on, say, 12 cores, we'd rather let other users run on the rest of the cores.

Research Computing and Enterprise IT



Enterprise IT vs Research Computing

Enterprise IT: HARDENED

- Secure
- Established technology
- Best practices
- 5 nines: 99.999% uptime = 5.25 **minutes** of downtime per year

Research Computing: SQUISHY

- Fast and flexible (turn on a dime)
- Cutting edge technology (= broken)
- In some cases, **no such thing** as best practices!
- 1.5 nines: 95% uptime = 18.25 **days** of downtime per year
 - This is the NSF's standard, from NSF solicitation 17-558:
“... [\$60M NSF-funded] production resources should be unavailable as a result of scheduled and unscheduled maintenance no more than 5% of the time.”
[OSCER: < 1%]



Enterprise IT: Why 5 9s?

- On Aug 8 2016, Delta Air Lines experienced a power outage in their Atlanta data center that lasted 5 hours.
 - Cost: \$150M (\$1M every 2 minutes of downtime)

<https://money.cnn.com/2016/09/07/technology/delta-computer-outage-cost/>



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Enterprise vs Research: Incentives

- Suppose payroll is going out tomorrow, and the payroll system goes down tonight.
 - On payroll day, what happens on the Enterprise IT people who are accountable for the outage?
 - Therefore, what must Enterprise IT people do to stay in business?
- Suppose Research Computing isn't on the cutting edge, and so proposals from the institution are less competitive.
 - Eventually, what will happen to the Research Computing team?
 - Therefore, what must Research Computing people do to stay in business?



Research: Why 1 ½ 9s?

- **Research Computing can afford to make mistakes:**

A system that's mostly up but crashes occasionally is fine.

- 1 day of HPC downtime = 10-100 lost grad student days
 - 1 grad student = ~\$59K/yr fully loaded with fringe+tuition+Indirect
 - => 100 grad student days = ~\$16K productivity loss **WORST CASE**
 - => ~\$300-\$1600 productivity loss per research group

- **Cost of 5 Nines vs 1.5 Nines:** 5-10x, but budgets are fixed – so the actual cost is cutting computing-intensive and data-intensive research productivity by 80-90%.

- **Therefore:** Let the machine go down from time to time, as a tradeoff for having more (but less resilient) resources, to maximize research productivity per year, at the cost of occasional lost days.

Research is the Enterprise Testbed

- Research Computing has only limited best practices.
- But, technologies currently being adopted by Research Computing are likely to become enterprise requirements in a few to several years.
- So, let Enterprise IT watch Research Computing make mistakes (which in Research Computing is a good thing), and use those observations to develop best practices for Enterprise IT.



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